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The New Cosmogony.

By J. E. GORE, F.R.A.S.

IN Laplace's Nebular Hypothesis, the original mass, from which the solar system was evolved, was supposed to consist of gaseous or meteoroidal material filling a space of spheroidal form and extending to the orbit of the planet Neptune, or somewhat beyond it. If a gaseous state be assumed the whole mass was supposed to be in hydrodynamical equilibrium, and rotating in a period equal to the period of revolution of the present farthest planet. We might also assume that the original mass consisted of a gigantic swarm of meteorites, for Professor G. H. Darwin has shown that such a swarm would have nearly the properties of a gas. On either assumption the mass would contract by its own gravitation, and, the angular velocity gradually increasing, the centrifugal force would in time flatten the spheroidal mass at the poles. From this flattened spheroid Laplace thought that rings would be detached at certain intervals, and these rings consolidating would eventually form the planets and satellites of the solar system as we now see them.

It has been shown, however, by Mr. F. R. Moulton, that the matter detached from the rotating gaseous spheroid would be "shed continually," and that no separate rings could be formed. This would occur whether we consider the original mass to have been gaseous or composed of meteorites. But supposing the rings to have been, by some miracle, detached from the parent mass, we should expect to find that the plane of Mercury's orbit would deviate less than the other planets from the average plane of the solar system; also that the orbits of the "terrestrial planets," Mercury, Venus, the Earth, and Mars, would be less eccentric, that is, more nearly circular, than those of the outer planets. But the known facts concerning Mercury's orbit are quite opposed to these conclusions. The inclination of its orbit to the plane of the ecliptic (7°) is greater than any of the large planets, and the eccentricity of its orbit (0.20) is only exceeded by that of some of the minor planets between Mars and Jupiter. Further, Moulton shows that the distribution of masses among the planets of the solar system indicates that the original nebulous mass must have been very heterogeneous and not homogeneous as Laplace's theory postulates.*

* *Astrophysical Journal*, March, 1900.

There are numerous other difficulties connected with Laplace's Hypothesis, and many attempts have been made to overcome them. But these efforts have proved only partially successful, and for some years past it has become increasingly evident that the hypothesis must be abandoned for something in better agreement with modern telescopic discoveries. The idea that the planets were formed by the condensation of rings detached from a nebulous mass is an hypothesis for which we find no warrant in the heavens. Laplace's idea of a Nebular Hypothesis was probably suggested by a consideration of Saturn's rings. But modern researches on tidal action tend to show that this wonderful system was not originally formed as a ring left behind by Saturn during the progress of condensation from the nebulous stage. More probably the matter composing the rings was originally separated from the planet in one mass. This mass being too close to Saturn to consolidate into a satellite—being within what is known as "Roche's limit"—was torn into fragments by the force of tidal action, and its particles were scattered round the planet in the form of a ring as we now see it. On this view of the matter the course of events was exactly the reverse of what was supposed to have happened in Laplace's Hypothesis. Instead of a ring being first formed, and then a number of small satellites from this ring, we must now conclude that a mass of matter was first detached from the partially consolidated planet, and that then this mass was broken up into small fragments by the enormous tidal action of the central mass.

We see in the heavens numerous forms of nebulæ—spiral nebulæ, planetary nebulæ, etc.—but there is no real example of a ring nebula. Those which have been termed "annular nebulæ" are most probably spiral nebulæ seen foreshortened. Of the numerous nebulæ recently discovered with the Crossley reflector at the Lick Observatory it has been found that "a large proportion are spiral, and that practically all the spirals are lenticular or disc-shaped. Many of them are relatively very thin."* At one time the photographs of the great nebula in Andromeda were thought to show signs of ring formation, but Dr. Roberts, describing his photograph of this wonderful nebula, says: "That this nebula is a left-handed spiral and not annular, as I at first suspected, cannot now be questioned; for the convolutions can be traced up to the nucleus, which resembles a small bright star at the centre of the dense surrounding nebulosity." Even the "ring nebula" in Lyra, which is sometimes adduced as an example of ring formation, was found by Professor Schaeberle, of the Lick Observatory, to be "a two-branched spiral which commences at the central star, and in a clock-

* Publications of the Astronomical Society of the Pacific, Dec. 10, 1904.

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wise direction emerges on opposite sides near the minor axis."‡ Even the apparent ring form of this nebula seems to be fictitious. Instead of being annular in shape, it appears to be a hollow spheroid, the ring representing the thickness of the shell. To anyone who still persists in maintaining the theory of ring formation in nebulæ it may be said that the whole heavens are against him.

It has always been difficult to imagine how rings could possibly be formed from the parent mass, considering the extreme tenuity of the original nebula. Computing from the total mass of the bodies composing the solar system, the density of the primitive nebulous mass—supposing it extended to the orbit of Neptune—would have been almost inconceivably small. The density of atmospheric air would be millions of times greater, and how rings could be formed in such a tenuous gas has always been a serious difficulty in the discussion of Laplace's Hypothesis. But a still more fatal objection has lately been found. The original idea was that the detached "rings" would at first break up into separate masses, and that these fragments would afterwards—by their mutual attraction—consolidate into planets. But from a mathematical investigation recently undertaken by the well-known American mathematician, Mr. John N. Stockwell, he finds that if two masses "are moving in the same plane and at the same mean distance from the sun, and are situated at an angular distance greater than 60° and less than 180° from each other, as viewed from the sun, their mutual perturbations will cause them to approach each other until the distance apart becomes equal to 60°"; and, further, if the two masses "are situated at an angular distance of less than 60° apart, as seen from the sun, their mutual perturbations will cause them to recede from each other until their distance apart becomes equal to 60°; and they will always remain in a condition of stable equilibrium at that distance apart, and will revolve round the sun for ever free from mutual disturbance."†

This result seems fatal to Laplace's Hypothesis in its original form, as the fragments of the ruptured ring could never have consolidated into a single planet. Mr. Stockwell adds: "The assumption by Laplace that the matter of which the ring was composed would concentrate by the mutual attraction of its different parts into a single planet or satellite is, therefore, not sustained by a rigorous calculation; and since the Nebular Hypothesis wholly fails to satisfy that requirement it evidently rests on no logical foundation."

Compelled, therefore, as we apparently are, to abandon Laplace's Nebular Hypothesis in its original form, are we, therefore, obliged to relinquish all attempts to explain the formation of suns and solar systems from the consolidation of gaseous matter? By no means. The heavens, which are clearly against Laplace's Hypothesis, are strongly in favour of a new theory, a new cosmogony, which will probably stand the test of mathematical analysis. This is the evolution of suns and systems from spiral nebulæ. Of the half-million nebulæ discovered with the Crossley reflector a large proportion are spiral, and the study of these remarkable and interesting objects will probably form an important portion of the work of future astronomers.

‡ *Nature*, August 6, 1903.

† *Astrophysical Journal*, No. 557, March 4, 1904. An asteroid recently dicovered (TG) has nearly the same period and mean distance as Jupiter, and seems to fulfil the conditions supposed by Stockwell. At present it is 60° from Jupiter, and may perh aps remain so.

Laplace's original nebula was gaseous, and a gaseous spectrum shows bright lines. But the spectrum of the spiral nebulæ is *continuous*, indicating that they have partially consolidated from the gaseous state. We can, therefore, easily imagine that masses might be thrown off or detached from the parent mass by the centrifugal force of the rotation. This seems much more probable than the formation of rings from a highly tenuous nebula. Photographs of spiral nebulæ show us masses in the act of being detached from the spiral branches. This is particularly noticeable in the photograph of the great spiral in Canes Venatici (51 Messier), in which we see the process going on before our eyes.

The theory of the evolution of suns and solar systems from spiral nebulæ has recently been investigated mathematically by Professor T. C. Chamberlin and Mr. F. R. Moulton. This investigation consists in an attempt "to test by an appeal to the laws of dynamics the consistency of the ring theory with known phenomena. Contradictions were uniformly found, and in some cases the results were so conclusive as to compel us frankly to abandon it as an untenable hypothesis."* An outline of this new cosmogony, called by Professor Chamberlin the "Planetesimal Hypothesis," and which certainly seems a great improvement on that of Laplace, may prove of interest to the general reader.

The *origin* of the nebulous mass from which the solar system is supposed to have been evolved was not considered by Laplace. He *assumed* its existence, and then proceeded to show, as he thought, how the sun and planets might have been formed from it by the consolidation of the nebulous matter in the course of ages. The origin of spiral nebulæ is, of course, unknown, but of their existence there can be no doubt. Photography has fully confirmed the discovery originally made by Lord Rosse with his giant 6 feet telescope. They are very numerous in the heavens. Professor Keeler thought that probably one-half of the nebulæ found with the Crossley reflector are spiral, and that "any small compact nebula not showing evidence of spiral structure appears exceptional." Spiral nebulæ were, of course, unknown to Laplace, and had he known of their existence we should probably never have heard of "ring formation."

A spiral nebula may possibly have been formed by a "grazing collision" of two solid or nebulous masses, or by the near approach of two bright stars. Supposing the near approach of a large body to another of larger size, the effect on the latter body would be the production of a gigantic tide on the side turned towards the approaching body, and another tide of almost equal size on the *opposite* side. These tides would produce explosions and eruptions of nebulous matter from the interior of the star, and Moulton shows that the ejected material would assume the spiral form. That a spiral form would be assumed by a rotating gaseous mass has also been shown by Herr E. J. Wilczynski, of Berlin.† Now it is a remarkable feature of spiral nebulæ that the spiral branches (usually two) almost invariably issue from the central nucleus at diametrically opposite points, thus agreeing with the new hypothesis. The spiral nebulæ which we see in the heavens are, of course, constructed on a colossal scale, and probably represent a stage in the evolution of star systems rather than solar systems like ours. But the principle would be the same in both cases.

In Chamberlin's "Planetesimal Hypothesis" the original nebulous mass "must have spread out in the

* *Astrophysical Journal*, October, 1905.

† *Astrophysical Journal*, Vol. 4 (1896), p. 98.

form of a relatively thin disc," and instead of being homogeneous, as in Laplace's Hypothesis, "it may have had almost any degree of heterogeneity." In this theory fluid pressure, which was of fundamental importance in Laplace's Hypothesis, is of minor consideration, "and no general shrinkage with loss of heat" plays any part in the evolution of planets from the parent mass.

Moulton shows that on this theory the resulting planets will all probably revolve round the nucleus in the same direction as the original rotation, and that the planes of their orbits "will nearly, though not exactly, coincide"; also that the orbits of the larger planets will show smaller deviations from the general plane than those of the smaller planets, like Mercury and the asteroids. This we know to be the case in the solar system. He shows that the present rotation of the sun is due to the original rotation of the mass from which it was formed, combined with the disturbance caused by the body which approached it, and that the more rapid rotation of the sun's equator is due to the same cause. He also shows that the larger the planet "the more nearly circular in general" its orbit would be; and this also agrees with the known facts of the solar system. The orbits of the so-called "terrestrial planets," Mercury, Venus, the Earth, and Mars, are, on the average, more eccentric than those of the large planets, Jupiter, Saturn, Uranus, and Neptune; and those of the small minor planets between Mars and Jupiter are still more so.

With reference to the rotations of the planets on their axes, Moulton shows that these would probably be direct, that is, in the same direction as the orbital revolutions, and that the inclinations of the axes of rotation to the planes of the orbits might be different for different planets. Any well-marked deviation from this rule might be expected in the outer planets of the system. This we see in the case of Uranus and Neptune, which have always proved stumbling blocks in Laplace's Hypothesis. We should also expect, he thinks, "to find the larger planets rotating more rapidly than the smaller," and this we know to be the case.

With reference to the satellites, the direction of their motion round the primary might, on the new hypothesis, be either direct or retrograde, according to circumstances. Retrograde motion might be expected in

The Spiral Nebula, 51 Messier.

(From a Photograph by W. E. Wilson, F.R.S.)

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satellites very remote from their primary and revolving in orbits of high eccentricity. This is the case with Phœbe, the recently-discovered ninth satellite of Saturn. The position of the satellites of Uranus could not have been predicted by the new theory, but Moulton thinks that "they do not definitely contradict it as they do the ring theory."

A satellite might also, on the new theory, revolve more rapidly round its primary than the primary rotates on its axis. This is the case with Phobos, the inner satellite of Mars, which revolves round the planet in 7 hours, 39 minutes, 15 seconds, while Mars' period of rotation on its axis is 24 hours, 37 minutes, 22.66 seconds, or over three times as long. This unusually rapid rotation of a satellite formed another objection to Laplace's Hypothesis, but it seems to be consistent with the new cosmogony.

With reference to the so-called "moment of momentum" of the solar system, Professor Chamberlin has shown that the greater portion belongs to the planets, and that Jupiter alone contains about 95 per cent. of the moment of momentum of the total mass within the orbit of Saturn. This is, according to Moulton, "an inevitable consequence of the spiral theory, but, on the contrary, the whole question of the moment of momentum is a rock on which the ring theory breaks."

According to the new cosmogony the outer portions of the matter ejected from the original body would evidently be formed from the surface portions of the star, while the matter which followed would "come mainly from lower depths," and would probably consist of materials of greater density. The smaller planets should, therefore, be cool and of high density, and the larger planets hot and of small density. This is also in agreement with the known facts of the solar system. The average density of Mercury, Venus, the Earth, and Mars is about $4\frac{1}{2}$ (water = 1), while the mean density of Jupiter, Saturn, Uranus, and Neptune is only 1.03, or about that of water. We know that the earth is cool, and that probably Mercury, Venus, and Mars are so also, while there is good reason to suppose that the large planets are in a highly heated condition.

On the whole, Moulton concludes that "the spiral theory is even now a good working hypothesis." It seems to explain satisfactorily all the observed phenomena upon which the ring theory was based, and many others which are in contradiction to Laplace's original hypothesis. "Nothing has yet been found which seems seriously to question its validity."

The new cosmogony will, of course, raise many very difficult questions in celestial mechanics, and will give a considerable amount of work to mathematical astronomers before it can be placed upon a satisfactory basis; but the work which has been already done by Chamberlin and Moulton shows clearly that the spiral theory is far superior to Laplace's Nebular Hypothesis, which should now be definitely abandoned and consigned to the limbo of unproved theories. The heavens show us thousands of spiral nebulæ, which are evidently in a state of rotation round a central nucleus, but which will probably take ages before they have finally consolidated into suns and solar systems. But ages are but moments in the evolution of the stars, and we need not expect to find much evidence of rotation and consolidation during the brief span of human history. Empires rise and fall, dynasties are founded and dissolved, but the heavens move on in their silent course, and the human race will probably have perished before the universe has reached its final destiny.

The Study of the Cell in the Higher Plants.

By H. A. HAIG.

(Continued from page 517.)

Shortly after the appearance of the spirem stage, the long thread of chromatin breaks up into separate threads, the number of which is constant for any given plant; these threads then take on the form of "loops,"

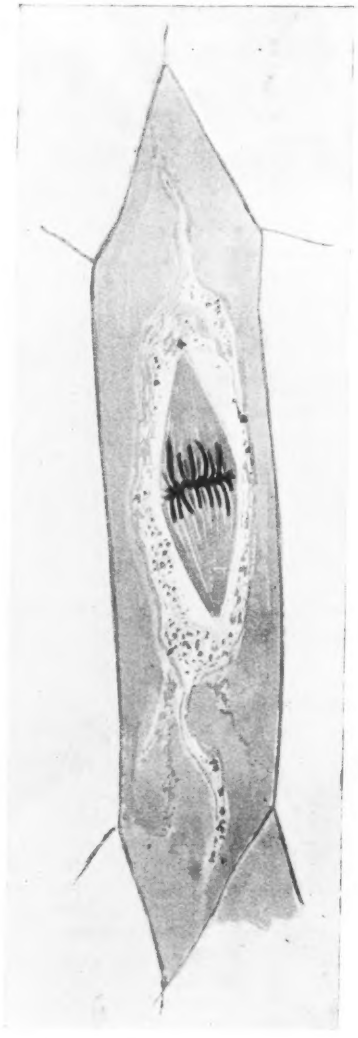

Fig. 6.

that is, become bent on themselves, and travel towards the central part, or equator, of the spindle, where they become arranged as a definite rosette, with the bends towards the centre, which, seen in optical section in a longitudinal section, has the appearance of a dark, central, transverse mass, with projecting portions on either side (see Fig. 6). This is consequently known

as the single rosette, or "monaster" stage. A most important change now takes place, in that each of these loops splits longitudinally into two equal loops, and the bends of these separate from one another, so that we have finally two systems of loops, arranged so that their bends are remote from, and their free ends

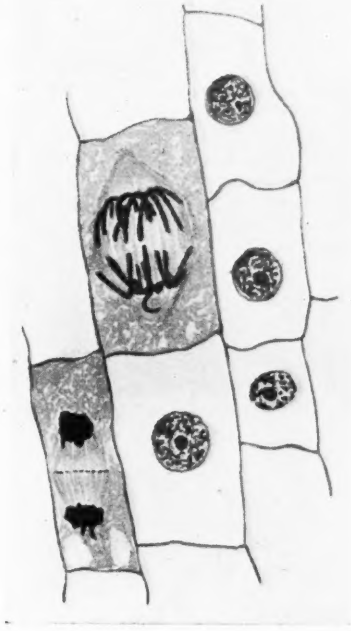

Fig. 7.

adjacent to, one another, each system preserving the general rosette arrangement.

In the next phase observed, these separate systems are travelling away from one another, and the appearance we get is that shown in Fig. 7, which represents this stage in one of the cells of the root-tip of the water-lily, with a more advanced stage in an adjacent cell. It will be seen that the loops are more or less symmetrically arranged with regard to the spindle.

When the loop systems have reached the opposite poles of the achromatic spindle, the stage known as the "diaster" stage is reached, and each of the loop systems then undergoes a series of inverse changes, *i.e.*, the loops lose their symmetrical arrangement, become thinner, and join up to form a spirem (dispirem stage), which finally breaks up once more into separate masses of chromatin, which become arranged upon a previously formed linin network. During these latter phases, the "cell-plate," or rudimentary partition wall,

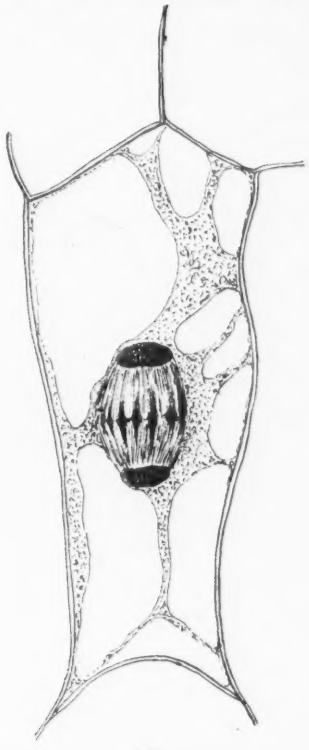

Fig. 9.

arises in the median equatorial plane of the nuclear spindle. Small thickenings appear at the middle points of the separate threads of the spindle, and these finally coalesce to form a well-marked cell-plate. We have before remarked that this is probably an instance of a direct transformation of kinoplasm into carbohydrate (cellulose).

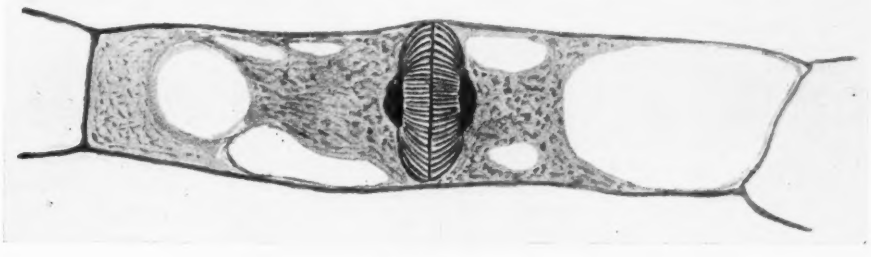

Fig. 8.

The later stages and the formation of the cell-plate are well shown in Figs. 8 and 9. Fig. 9 is from a photo-micrograph and the equatorial thickenings on the spindle-fibrils can be easily distinguished; the daughter-nuclei become further differentiated by the development of fresh nucleoli, and the possible resumption of a nuclear membrane.

It is in this manner that new cells are formed by the

process of karyokinesis; and we see that it is a method whereby a very accurate redistribution of chromatin takes place for the formation of equal daughter-nuclei in each of the freshly formed cells. The process has been gone into somewhat fully on account of its importance. We pointed out some way back the fact that economy was carefully attended to in the higher plants, and we have here a means whereby each fresh cell is appointed equal quantities of nuclear substance, so that each cell has equal chances of still further division, granted the necessary conditions of an adequate supply of food-materials, including water and oxygen. We see, moreover, what an important structure the nucleus is in the case of these cells of the higher plants; whereas, in those lower plants in which cell-division takes place without mitosis, the nucleus seems to take a less important place, although it may still possess a very definite function as regulator of nutrition or a cell-centre of some sort.

4.—The further modification of a cell, as dependent upon its position, and the ultimate function it has to fulfil.

The several tissues of which a plant is made up, such as the assimilatory, conducting, and reproductive, are characterised to a certain extent by the form and functions of their component cell-units. It is not intended here to go into a detailed description of the microscopical features presented by these various types, but rather to try and elucidate some of the causes which determine the wide divergencies from the simple form which can be effected in a living cell.

The mass of embryonic tissue in a young bud, or at the apex of a rapidly growing stem, is mainly composed of the kind of cell we started by examining in this article, *i.e.*, one in which we can recognise cell-wall, protoplasm filling the cell-cavity, nucleus and plastids. Each of these cells is capable of active division, and, up to a certain point, maintains its simple characteristics. But a little way distant from the apex, towards the central parts of the young tissue—in other words, the outer boundary of that portion of the young axis known as the "plerome"—we find certain of these cells undergoing elongation, thickening of their cell-walls with characteristic markings on them, and a gradual diminution in protoplasm and other cell-contents. The cells, in fact, are becoming slowly converted into vascular elements continuous with those of the main stem, and the causes determining this transformation are partly dependent upon the position of these cells, partly upon the nature of the food-materials supplied, and in part, perhaps, upon a certain inherent capacity possessed by the protoplasm in these regions. That this capacity in any given part admits of modification, is seen in the case of a formation of adventitious organs (such as roots) from cuttings taken from species of begonia and other plants, an entire plant being in this way reproduced; and in cases like this we see the effect which sudden change has upon the various parts of a plant, and the great adaptability of protoplasm to altered conditions of existence. Position is, to some extent, a factor in the determination of function, as a given cell is surrounded by others of the same tissue, which can influence, and perhaps regulate, its metabolism. But there are a few apparent exceptions to this, as in the case of cells known as "idioblasts"—that is, cells more or less different in structure and functions from those by which they are surrounded. Such are tannin-cells, cells of oil-glands, and those in which large masses of crystals sometimes separate out. It would seem here as if the protoplasm of a given cell were capable of modifying its action in such a way as to take on the additional or sole function of manufacturing substances, which may or may not be of future use to the plant; but as to why protoplasmic action should in these cases be modified is difficult to explain, and explanation would only become possible on the theory of the mutual inter-dependence of cells.

In the embryo-plant, certain rudimentary tissues are laid down, such as those composing radicle, young stem, and leaf rudiments; there are grounds for assuming that the formation of these embryonic organs is governed to a certain extent by a hereditary influence transmitted with the protoplasm, from which the cells composing these organs are ultimately produced. Later on, when external surrounding conditions begin to act upon these cells, we find that the hereditary influence loses to a certain extent its value, and the further modification of the cell depends more and more upon these conditions and upon the final position relative to other tissues which it takes up.

We find in some cases that hereditary characters are retained up to a certain point, but that these characters tend slowly to become modified, even to complete absence, by the predominant effect of other conditions; such an instance we find in prefertilisation stages in the embryo-sac of the Angiosperms, where the antipodal cells formed during the divisions of the nucleus of the embryo-sac represent a former prothallium, thus showing to a certain degree a relationship of the Angiosperms with the Gymnosperms, and Cryptogams. But the cells of this prothallium are now so reduced and few in number that, in time, they will probably be non-existent.

We cite this case simply to show that hereditary influences are at work during embryonic stages, and that we must not lose sight of this possibly important factor in cell-modification. The cell, however, is modified in the various parts of a plant in order to be able to fulfil certain functions, and this change is completed when the various organs have, under the influence of external conditions, attained their perfection. As to the causes of this modification, we have seen that some may have their origin in a certain hereditary capacity impressed upon the cells of an embryo-plant, and yet others are certainly due to the influence exerted by surrounding conditions. Some remanent hereditary capacity must likewise be assumed to be present even in the protoplasm of cells of even highly developed organs, so that we must not think subsequent modification during growth entirely due to external conditions.

Moreover, it is important to remember that the adaptability of protoplasm is limited to young cells, for a cell that has been already modified to a certain extent will probably, even if placed under entirely new conditions, proceed upon the same lines of development as before, or else be unable to exist at all under these altered conditions.

Having now examined the cell under the four headings set out at the beginning of this article, we must further try and gain an idea of the general working of the cell looked at from the point of view of a unit depending upon the existence of other cells, as well as upon its own labours. By means of the various tissues into which a plant may be divided, a very accurate division of labour is effected; some of the work done by living cells is manifested in the formation of units that soon become devoid of protoplasm, such as in the wood of stem and root, but these elements have a very

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definite function, *i.e.*, as water-carriers from the root upwards. Of the cells that remain living units throughout their whole existence, some are set off as assimilators of carbon from the atmosphere, others as the further elaborators of this carbon into substances, such as sugar and starch, that can be later made use of by the cells. The cells set aside for reproductive purposes arise in parts of plants specially constructed for this, and the origin of these cells is to a large extent governed by hereditary influences, and partly by certain peculiarities in nutrition. Their further behaviour is also upon definite lines, and the formation of the egg-cell, the influence of fertilisation, and the whole of the phenomena concerned in the production of the embryo point strongly to the influence of heredity.

The dependence of any one part of a plant upon any other is easily seen in the fact that the leaves and other green portions of a plant are the only organs in the higher plants (speaking generally) whereby carbon is assimilated, and without the leaves the plant would certainly die. Likewise the dependence upon the roots for the greater part of the water taken in is another instance of the same principle.

The cells of the leaf manufacture from raw-materials supplied from below, together with carbon obtained from the carbon dioxide of the atmosphere, the substances needful for the nutrition of the protoplasm in other parts of the plant; the leaves are dependent for their water and salts upon the roots, which take in these from the soil outside, and upon the wood, by the mechanical action of which, aided by root-pressure and the transpiration current,* the water and salts are conducted. By taking instances such as these, it may easily be shown that the various cells of a plant are more or less dependent upon one another, and work towards the same end, namely, the adequate growth and extension of the whole organism, until such time when the reproductive organs have developed and made good the certainty of extension of the species.

Moreover, the instances of transmission of stimuli which we have already studied show us that a very delicate and rapid means of response exists in some cases, which in the Sundew and others is of the highest importance to nutrition, and the reaction of certain parts of plants to injury, by the formation of cushions of callus, whereby injurious evaporation is prevented, is a well-known example of the working of special cells for the benefit of the whole community.

Thus, by an examination of the individual cell, and by the employment of certain biological reasons which are found to hold good and tally with results obtained by experiment, it is possible to gain a little insight into the manner in which the cell works; we see that protoplasm is the working substance, that external stimuli produce measurable effects, and that growth as a whole depends upon the results of these stimuli.

There are undoubtedly many undiscovered factors at work tending to produce the final result, and some of these, it is to be hoped, will be elucidated by future investigations. At the same time it must be remembered that here we have only attempted to give an outline of the value of the cell to the organism; but that such an outline is indispensable if we wish to enter into further investigations.

* The transpiration current is brought about chiefly by the evaporation of water from the leaves; this starts a sort of osmotic action, water being drawn up from lower cells of progressively decreasing concentration.

The Study of Heredity.

ALTHOUGH some of the phenomena of heredity have been familiar to us for so long, our acquaintance with them has really been of a very superficial kind. It has been recognised that in general the offspring tend to resemble their parents, and by observation of large masses of individuals we have even been able to arrive at a measure of the strength of this tendency; but of the inheritance of some character in individual cases almost nothing has been known. It is only within the last few years that the attempt to formulate "laws," such as will give a concise description of the observed phenomena, has met with any success.

The object of this article is to give an account of the principal methods by which the work has been carried on, and briefly to indicate some of the principles upon which the study of heredity is based, without attempting to enter at all fully into the details which must be sought in more technical papers. There exist at the present time two schools, which attack the problem from very different standpoints and by very different methods of investigation.

The Statistical Method.

The foundation for the work of the present school of Biometricians was laid by Francis Galton when he applied the methods of statistics to the treatment of the phenomena of heredity and variation.

A series of observations is made upon some one character throughout a very large number of individuals of some race. The character chosen is susceptible either of quantitative measurement or of reference to some group in a qualitative scale. The stature and the eye-colour of man may be cited as instances of two characters which were studied, among others, by Galton.

The measurements are carried out upon a large number of individuals taken at random from among the general population. The results are arranged in a table showing the number of individuals which come under each degree of our scale, and may be represented graphically by plotting on squared paper the vertical ordinates representing the number of individuals who possess the character in the degree indicated by the corresponding abscissæ.

The larger the number of measurements the nearer the tops of the ordinates are found to approximate to a smooth curve. The character which is borne by the largest number of individuals, that is, which corresponds with the highest point of the curve, is known as the mode: and the curve will be one of three general types according to the position which the mode occupies. The mode may be median, the curve being symmetrical about the mean character; it may be nearer either end of the curve, representing graphically the fact that divergence from the mode in one direction is more common than in the other; or, finally, the curve may show more than one peak, the intermediate values occurring less frequently. This curve represents a population which may be divided into two or more groups, each with its own mode. Intermediate forms are rare, so that there is generally no difficulty in placing any individual in its proper group. Variation of this type is known as "discontinuous," as opposed to the continuous variation represented by curves of the first two types.

The range of variation of the character throughout

the race is represented by the length of the base line upon which the curve is erected. The frequency with which any variation within that range occurs will be at once seen to depend upon the shape of the curve, its steepness, &c. Suppose M to be the mean value of the character as represented in our race; then the measure of the character in any individual may be written $M \pm D$ where D is the *deviation* of the character from the mean value for the race in that individual. The mean value of the squares of *all* the individual deviations represented in the curve is the square of a factor known as the *standard deviation*, which gives a measure of the variability of the character in the race under observation. Observation shows that, in general, related individuals tend to resemble one another, in regard to some one character, more nearly than they resemble all the other individuals of the same race. This resemblance between the characters of related individuals is a case of *correlation*. It is found, moreover, that if one individual possesses the character in a certain degree, there is a "most probable value" for the same character in his relations. Inspection of the curve will suggest to us that in general this "most probable value" will lie between the value of the first chosen individual and the mode. This is found to be the case, and this phenomenon is known as *regression*.

Regression and correlation may be represented graphically by plotting the values of the first chosen individuals with the mean values for some one group of relations, say, for their brothers, or for their sons.

If the corresponding values which are plotted together are identical the curve will form a diagonal to the square, correlation will be complete, and regression will be absent; but if, as is always the case, correlation is only partial, the curve will form an angle with the diagonal which represents complete correlation, the angle being greater the less the correlation and the greater the regression are. The slope of this line gives a measure of the correlation known as the "coefficent of correlation," which is taken as unity in the hypothetical case where correlation is complete. In practice the coefficient of correlaton is always a positive fraction less than unity.

The numerical expression for correlation and regression thus obtained may be applied to the special case in which the relation between the first-chosen individual and the group of relatives is that of parent and offspring. The character of the parent being known, the coefficient of correlation and the standard deviation for the race may be used to obtain a value for the probable character of the offspring, that is, a value to which the mean of the values for all the offspring will approximate more and more nearly as the number of offspring is larger and larger.

The same method may be applied to the case of biparental inheritance, when we require to find the probable character of the offspring, taking into account the known characters of both parents. Taking as our example the case of the stature of man, it will be noticed at once that the greater mean stature of the males, as compared with that of the females, introduces a factor for which allowance must be made. Men are, on the average, taller than women, hence in calculating the probable stature of sons from the known statures of the father and mother, a correction must be applied to the observed stature of the mother.

Galton showed how this might be done by replacing the observed stature of the mother by a value representing the equivalent stature for the male. Prof. Karl Pearson has shown that in general the probable character of the offspring may be calculated by the use of what is known as a "mid-parent"; that is, a single artificial parent whose characters are calculated so as to combine those of the father and of the mother into one.

From the study of biparental inheritance by means of the method indicated above we may pass directly to the "Law of Ancestral Heredity," which, first formulated by Francis Galton, has been somewhat modified and extended by Karl Pearson. In this law, use is made, not only of the correlation between offspring and parent, but of that between offspring and grandparent, and between offspring and more remote ancestors, in order that the probable character of the offspring may be calculated with the greatest possible approximation to the truth.

By means of the method already mentioned a "mid-grandparent" is formed from the four grandparents; a "mid-great-grandparent" from the eight great-grandparents, and so on for the more remote ancestors.

Now it is obvious that as the generations are traced backwards the ever-increasing number of ancestors will, except in extreme cases of in-breeding, approximate more and more closely towards a fair sample of the whole population at that period, so that the mid-parent of, say, the 10th generation, will show little or no deviation from the racial type of that period.

Francis Galton's "Law of Ancestral Heredity" was the first attempt to give a numerical expression which should indicate the proportion in which each generation of the ancestry contributes to the characters of an individual.

The Law was enunciated thus: "Each parent contributes, on an average, one quarter or $(0.5)^2$, each grandparent one-sixteenth or $(0.5)^4$, and so on, and generally the occupier of each ancestral place in the nth degree, whatever be the value of n contributes $(0.5)^{2n}$ of the heritage." These numbers form a geometrical series, of which the sum of an infinite number of terms is unity. Professor Pearson has shown that some modification of this statement is necessary, and has introduced a quite general mathematical expression for the Law of Ancestral Heredity, which avoids certain assumptions made in Galton's enunciation of the law. For the particular case assumed by Galton, the original series of factors would be replaced by the series

$$0{\cdot}3,\ 0{\cdot}15,\ 0{\cdot}075,\ 0{\cdot}0375\ \ldots\ {\cdot}6\times(\tfrac{1}{2})^n$$

for unions where the sexes are equipotent, blend their characters and mate pangamously.

Want of space compels us to turn now to the second part of our subject. The previous pages have given no more than the briefest outline of the methods adopted in the statistical treatment of heredity. I would suggest that any readers who may wish to make themselves more familiar with the subject should refer to Prof. Pearson's book, "The Grammar of Science," in which the theory is simply explained, and to numerous publications of the same author in the *Transactions of the Royal Society*. Further information may be obtained in "Biometrika" (Camb. Univ. Press), a journal in which the results obtained by the statistical method are published from time to time.

The Mendelian Hypothesis.

It was as long ago as 1865 that Gregor Mendel, who was then Abbot of Brünn, communicated the results of his experiments in plant hybridisation, which he had pursued for eight years previously, to the Brünn Society of Naturalists.

For 35 years his work, although of such fundamental importance, remained entirely unrecognised, until in 1900 it was rescued from its obscurity by the simultaneous discoveries of de Vries, Correns, and Tschermak. It was mainly by the simplicity of his experiments, in which the inheritance of some particular character was traced through several generations, that Mendel was able to arrive at the hypothesis which has revolutionised our conceptions of the physiology of heredity. Mendel's work was carried out by means of artificial fertilisation in a race of plants chosen, after careful preliminary work, as suitable for the purpose for which it was used.

"The experimental plants must necessarily:—

"(1) Possess constant differentiating characters.

"(2) The hybrids of such plants must, during the flowering period, be protected from foreign pollen, or be easily capable of such protection.

"(3) The hybrids and their offspring should suffer no marked disturbance in their fertility in the successive generations."*

Such plants Mendel found in the Garden Pea (*Pisum sativum* and its varieties). From among the many varieties of peas he chose pairs of varieties, for artificial cross fertilisation, in such a way that the members of each pair differed from one another in some one definite character. The characters selected for experiment were:—(1) The shape of the *ripe* seed, whether round or deeply wrinkled; (2) the colour of the cotyledons in the *ripe* seed (*i.e.*, the colour of the seed *after* the removal of the seed coat); whether green or yellow; (3) the colour of the seed coat, whether white or some shade of brown; (4) the shape of the ripe pod, whether simply inflated or deeply contracted between the seeds; (5) colour of the unripe pod, whether green or yellow; (6) the position of the flowers, whether distributed along the stem, or crowded near the top; (7) the length of the stem, whether 6 to 7 feet or $\frac{3}{4}$ to $1\frac{1}{2}$ feet.

Each pair of the above characters were united by cross fertilisation. Mendel found that in each case one only of the two characters appeared in the hybrid offspring, the hybrid character resembling that of one of the parental forms so closely that "the other either escapes observation completely, or cannot be detected with certainty. This is found to be true whichever variety be used as the seed parent; that is, reciprocal crosses give identical results." The character which thus appears was termed by Mendel the *dominant*, the character which is hidden being the *recessive*.

The next generation is obtained by self-fertilising these hybrid plants. The result of this is that in these peas the offspring, instead of being all alike, break into two forms, resembling respectively the two parental forms. The ratio in which these two forms are obtained is, within the error of observation, that of three dominants to one recessive.

Take, for example, Mendel's second experiment of crossing two varieties differing from one another in the colour of the cotyledons. The cotyledons are, of course, the first leaves of the young plants, so that this particular cross has the advantage that the characters of the offspring can be determined in the same season that the cross is made.

Mendel made 58 crosses, yielding 253 seeds, all of which had yellow cotyledons. R. P. G.

(To be continued.)

* Bateson's translation of Mendel's original paper. See "Mendel's Principles of Heredity." Camb. Univ. Press. Page 42.

The Origin of Birds.

By W. P. PYCRAFT, A.L.S., F.Z.S.

THAT birds and reptiles, in spite of their apparent differences to-day, are really very closely allied, admits of no dispute. A comparison of the skeletons alone of the two types would be sufficient to demonstrate this, while the brain, vascular, and urino-genital systems furnish no less striking testimony. But, apart from the indubitable evidence to be obtained from living birds, other and even more striking testimony is to be obtained from the remains of fossil forms.

This evidence carries us back to Jurassic times, the oldest known fossil bird—Archæopteryx—having been obtained from the lithographic slate of Solenhofen, in Bavaria.

This bird more nearly resembles the reptiles than any other known form. So much so, that undue and unwarrantable use has been made of the fact, many writers having endeavoured to show that it was more reptile than bird, a contention which becomes ridiculous when the facts are carefully considered. Two specimens of this remarkable bird only are known—belonging to as many species—the first to be discovered being now in the British Museum, the second, and most perfect, in the National Collection of Berlin. With the specific distinctions we have nothing to do here, but both agree in having the jaws armed with teeth, and a long, tapering, lizard-like tail; but this, like the rest of the body, bore feathers.

One of the "Pro-Aves."

Of all the accounts that have been given of this patriarch of the bird world, only one can be regarded as accurate, though on many occasions one or other of them have been described by men whose powers of interpretation have in other ways been more severely tried. It is on their descriptions that the inaccurate and sometimes grotesque figures which adorn text-books of comparative anatomy and natural history have been based. So profoundly impressed do these authorities appear to have been by the presence of teeth in the jaws, the long tail, the armature of claws on the wings, and the fact that traces remain only of the wing and tail feathers, and of the feathers of the legs, that they contended that these ancient types must have been clothed, as to the head, neck, and trunk, with scales, and as to the rest of the body with feathers. A contention as wildly improbable, surely, as it would be to insist that, from the absence of all traces of muscles, these primitive creatures had not yet acquired muscular tissue.

Nevertheless, we have, in this primitive type, not

only a remarkable link in the chain of evidence as to the source from which birds derived their origin, but also a most valuable key to some essentially avian characters which would otherwise have had to be explained on mere conjecture.

Notwithstanding, then, the unmistakable evidence of reptilian descent furnished by these two fossils, we must await the discovery of yet earlier fossils before we can obtain any certain evidence as to the character of the incipient birds—the pro-aves. Meanwhile, we venture to make a forecast as to the probable appearance of these ancestral types. But all our inferences in this matter must be inspired by, and based upon, that strange, kite-tailed form, Archæopteryx.

From what we know of other types of vertebrates we may safely assume that these ancestral birds were of small size, and were probably also arboreal. And from the unmistakable signs of the shortening of the body in modern birds, the trunk was also relatively longer, as it certainly was in Archæopteryx. From these two inferences we may conclude, with some degree of probability, that these creatures, these birds "in the making," had substituted leaping for climbing about the trees. And from this there was but a short passage to leaping from tree to tree. In these movements we may reasonably suppose the fore-limbs were used for grasping at the end of the leap. The use of the fore-limb for this work would naturally throw more work upon the inner digits—1–3—so that the work of selection would rapidly tend to the increased development of these, and the gradual decrease of the two outer and now useless members. Correlated with this trend in the evolution, the axillary membrane—the skin between the inner border of the arm and the body—became drawn out into a fold, while a similar fold came to extend from the shoulder to the wrist, as the fore-limb, in adaptation to this new function, became more and more flexed. While the fingers, upon which safety now depended, were increasing in length, and growing more and more efficient, they were, at the same time, losing the power of lateral extension, and becoming more and more flexed upon the fore-arm. And the growth in this direction was probably accompanied by the development of connective tissue and membrane along the hinder, post-axial border of the whole limb, tending to increase the breadth of the limb when extended preparatory to parachuting through space from one tree to another, long claws being used to effect a hold at the end of the leap.

The hind limbs, though to a less extent, were also affected by the leaping motion, resulting in the reduction of the toes to four, and the lengthening, and approximation of the metatarsals 2–4 to form a "cannon" bone.

The body clothing at this time was probably scale-like, the scales being of relatively large size and probably having a medium ridge, or keel, recalling the keeled scales of many living reptiles. Those covering the incipient wing, growing longer, would still retain their original overlapping arrangement, and hence those along the hinder border of the wing would, in their arrangement, simulate in appearance and function the quill feathers of their later descendants. As by selection their length increased, so also they probably became fimbriated, and more and more efficient in the work of carrying the body through space.

There is less of imagination than might be supposed in this attempt at reconstructing the primitive feather, inasmuch as there is a stage in the development of the highly complex feather of to-day which may well represent the first stage in this process of evolution. Creatures such as are here conjured up would bear a somewhat close resemblance to Archæopteryx, and it is contended that the discovery of earlier phases of avian development, phases preceding Archæopteryx, will show that this forecast was well founded. But in Archæopteryx, it is to be noted, the feathers differ in no way from the most perfectly developed feathers known to us.

While the external form and mode of life of these primitive, hypothetical types was slowly changing, no less fundamental progress must have been taking place with regard to the internal organs, more especially the nervous, respiratory, and vascular systems, and changes in the direction of a larger brain and a more perfect system of oxygenating the blood. This last was effected by the acquisition of a four-chambered heart, an approach to which has been made only in the living crocodiles among the reptiles. With the addition of this fourth chamber the high temperature and phenomenal activity of the birds came into being, but for reasons for which no explanation is yet forthcoming, the reptilian character of the blood corpuscles was, and is, retained. That is to say, the red corpuscles still retain the nucleus in common with all the lower vertebrates, while in the warm-blooded mammalia—also of reptilian descent—these nuclei have been lost.

But whether these pro-aves are to be regarded as descended, in common with the reptiles, as a collateral branch of the same stock, or whether they sprang from some primitive but true reptile is a point too subtle for present determination.

CORRESPONDENCE.

Red Hills Exploration Committee.

To the Editors of "KNOWLEDGE & SCIENTIFIC NEWS."

SIRS,—Presumably many of your readers who reside within a few miles of the East Coast are acquainted with the patches of burnt earth, scattered along the margin of many creeks and saltmarshes, especially in Essex, and generally known as "Red Hills."

Their origin, date, and purpose have formed the basis of many a debate, and brief accounts of some of them have from time to time been published, but no satisfactory solution has yet been found of the varied problems they present to a wide range of students.

A Committee has now been formed under the auspices of the Essex Archæological Society and the Essex Field Club for the systematic study of these interesting relics of antiquity and the settlement, if possible, of the many questions relating to them.

As a first step, a complete list of Essex examples will be prepared and their positions marked on a map which will be published if funds permit.

As the questions to be investigated are not purely archæological, but touch the wide fields of geological conditions and physical changes, it seems desirable to make the proposed exploration generally known.

It is hoped that the Society of Antiquaries of London will make a grant in aid, but further assistance will be very welcome, as the Committee's operations will necessarily be limited by the amount of funds available.

The Committee consists of the following:—F. Chancellor, F.R.I.B.A.; Miller Christy, F.L.S.; William Cole, F.L.S.; Rev. J. H. Curling, B.A.; W. H. Dalton, F.G.S.; T. V. Holmes, F.G.S.; Dr. H. Laver, F.S.A.; Dr. Philip Laver; Prof. R. Meldola, F.R.S.; Chas. H. Read, F.S.A.; Col. O. E. Ruck, R.E.; F. W. Rudler, I.S.O., F.G.S.; H. Wilmer, C.E., Hon. Sec. and Treasurer.

I. CHALKLEY GOULD, F.S.A.,
Chairman of Committee.

Royal Societies' Club,
London, S.W.

The Renowned Horn of Ulphus.

IN the vestry of York Minster is preserved the horn of Ulphus, which is of ivory, curiously carved, and was formerly ornamented with gold mounting. It is a valuable relic of ancient art, and dates back to a period before the Conquest. An inscription in Latin, on the horn, states that Prince Ulphus gave it to the Church of St. Peter with all his lands and revenues.

Ulph was the son of Thorald and lord of the greater part of Eastern Yorkshire. Tradition says that this Saxon Prince piously presented all his lands to God to hinder his two sons from quarrelling about their possessions. The gift was accompanied with the ceremony of kneeling at the altar rails and drinking the

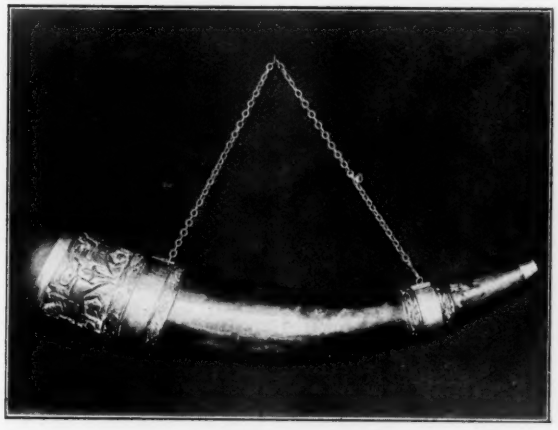

Photo. by Duncan & Lewin, Minster-Gates.

The Horn of Prince Ulphus in York Minster.

wine with which he had filled the horn. He then laid and left it on the altar, by tenure of which his lands were held by the Abbey.

Encircling the wide end of the horn is a belt of carving representing griffins, a unicorn, a lion devouring a doe, and dogs wearing collars. The griffins stand on either side of a tree, recalling the sacred tree of Assyrian sculpture.

During the Civil Wars, the horn disappeared, but was afterwards found by Lord Fairfax, whose son restored it to the Minster. The golden ornaments had been stolen, but a silver-gilt chain and bands were attached to it by the Chapter in 1675.

Electrical Nitrates and Fertilisers.

AT present the world's wheat supply depends chiefly on the continued productiveness of a strip of territory in Chili, which produces the Chili saltpetre that serves as a fertiliser. It is the aim of commercial chemistry to produce an artificial fertiliser which can compete with this substance, and for 15 years at least chemists have been trying to find some way of cheaply "fixing" the inexhaustible nitrogen of the air, so as to combine it into a substance that will be an "artificial nitrate." Experiments were first made at Niagara, because electricity was cheap there and the method of making artificial nitrates which first suggested itself to chemists was that which has an analogy to the lightning flash. The lightning as it passes through the air burns the nitrogen and oxygen together so as to leave behind it a streak of nitrous acid, or by burning up the water vapour, a streak of ammonia. Could not the electric arc or spark do the same? So the chemists, Bradley and Lovejoy at Niagara, Birkeland and Eyde in Norway, Rossi in Italy, and Ehrlwein on behalf of the restless experimenting firm of Siemens and Halske, have tried by using electricity, sometimes to form a great number of sparks in a chamber filled with nitrogen, sometimes by using one very large arc, to burn or concentrate this nitrogen into a nitrate, and then (generally), while in this form, to unite it with some basic substance. They have had a greater or smaller measure of success, limited by the cost of their productions; and their methods are described in a valuable summary by Professor Kennedy Duncan. But the goal of commercial success can only be reached through cheapness; and the electrical energy costs too much for the amount of electro-chemical manure produced. Is there any other way? Professor Adolph Frank says there is. He proceeds by the calcium method, which is to force the nitrogen to unite with this metal, one of the few substances in nature with an affinity for nitrogen. By heating red-hot calcium carbide he found it could be got to unite with the nitrogen of the air to form a substance called calcium cyanamide; and calcium cyanamide—to examine its properties no further—can be used as a fertiliser, and is a good one. The fertiliser of the future, then, may be calcium cyanamide, the price of which depends on calcium carbide. The price of both depends, again, on the cost of the electrical energy used in their manufacture; but this method produces by-products in such numbers and variety that the cheapness of production may be said to grow daily.

Photography.

Pure and Applied.

By CHAPMAN JONES, F.I.C., F.C.S., &c.

Self-Recording Instruments.—An apparently very advantageous method of using sensitive paper in self-recording instruments is described by R. Nimführ. Printing-out paper is used, and first smoked by the flame of a paraffin lamp, so that the needle point in moving against it traces a line in the soot and lays bare the surface of the paper. The record is then exposed to light to darken the exposed parts, washed to remove the soot, and fixed. The method is stated to work excellently, giving the finest lines. The smoking should present no difficulty if the paper is kept meanwhile in close contact with a metallic surface. The use of a printing-out instead of a development paper very much reduces the precautions necessary in its manipulation with regard to light, and the protecting layer of soot renders the arrangement practically independent of light and unaffected by it.

Snap-Shots Indoors.—The absurdity of trying to get negatives with rapid shutter-exposures inside ordinary buildings has often been commented on, yet it may be

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possible, and an illustrated article by Mr. Arthur Payne, published a few weeks ago in the "British Journal of Photography," gives some idea of the necessary conditions. The plates used were bathed in an "orthochrome T" solution, and so made extremely sensitive, especially to yellow light. The lens had an aperture of *f*/3.6 (that is, five or six times as large an aperture as an ordinary "rapid" lens), and the exposure was one-tenth of a second. The subjects were figures on the stage, lit in the ordinary methods during public performances. The development was done at 75° Fahr., and the negatives were very thin. As vigorous a transparency as possible was made in the camera, using a slow plate, and the process was repeated on the transparency to get another negative. By then using a printing paper that gives great contrast, the final print was obtained. That is, with such a rapid plate, fast lens, powerful light, and forced development, the one-tenth of a second gave such underexposure that it required three consecutive struggles after vigour to get a suitable print.

Critical Focussing.—The focussing screens generally supplied with the best cameras are quite serviceable for the more ordinary purposes, including the photography of architectural subjects, but fail altogether when really critical definition is required. They fail because they are not flat, and also because the grain is not, as a rule, fine enough. A home-made screen will be found better, and can be prepared without the exercise of much skill, by getting two pieces of polished patent plate glass of suitable thickness and the required size, and grinding one side of each together until they present, when washed and wiped, an evenly greyed surface. The grinding is done by putting one piece of glass down on a flat board with small brads to prevent it slipping about, but not projecting so high as the upper face of the glass, and working the other glass with a circular motion on it, with fine emery and water between. The emery should be the finest that will cut, obtained by elutriation. The finer the grain of the screen the less bright is the image that falls on it, but the finer the detail, therefore such a screen as described might not be so good for portraiture and views as one with a coarser grain.

But for really critical focussing the surface of the screen must be polished so that the image may not be broken up at all. It is often stated that in such a case a high-power eye-piece must be used, that the accommodation of the eye may not introduce uncertainty. This is an error, for no practical eye-piece could prevent a normal eye from accommodating or focussing itself so as to clearly see the image as it was moved over a considerable distance. There must be marks on the screen surface, and these marks must be seen in sharp focus at the same time as the image; then the marks and the image will be in the same plane irrespective of the power of the eye-piece and the accommodating power of the eye. A common suggestion for getting a clear spot on a ground glass screen, is to cement a microscope cover glass to it with Canada balsam. If this is done a few lead pencil marks should be made first to focus the eye-piece on. I have tried this method a few times, but never succeeded. Of course, the glass and balsam that the light passes through when focussing, but not when exposing the plate, will cause the image plane to be different in the two cases, and whether or not this is the reason, the fact remains that I have not found this method reliable. If a clear or nearly clear spot is wanted on a ground glass screen, the method that is the most successful with me is to rub the part with grease until the desired effect is produced. I have tried a great many oils and fats for this purpose, and find that the simple cerate of the Pharmacopœia is the best.

If the whole screen is to be polished, then a selected piece of patent plate is employed without grinding it, and it remains to get the lines on its surface. It will be found advantageous if these lines are ruled in groups of three, with a greater space between each group and the next than between the members of the group. No method of hand ruling with a diamond has been successful with me, the lines are broken and irregular, but perfect results may be obtained by etching. For this purpose, the selected piece of glass is thoroughly cleaned and dried, then warmed so that when rubbed with a piece of wax, the wax melts and coats the glass. When cold, the film of wax should be complete and thin. To make the lines, which, of course, must go quite through the wax, a needle is not so good as a sharp knife, and this should be drawn along against a straight-edge, exactly as if cutting, but with a light pressure, only just sufficient to go through the wax. For the etching, a piece of thin sheet-lead is bent up at its edges with the fingers, to form a shallow tray. This should be placed out of doors on something level and firm, enough strong sulphuric acid put in it to form a shallow layer, and powdered fluorspar scattered evenly on to it. Hydrofluoric acid is soon evolved, and the glass, with its waxed side downwards is placed over it, resting on the edges of the dish. In a short time, a minute or two, perhaps, the etching will be sufficient. The glass is warmed, the melted wax wiped off, the glass well cleaned, and the lines examined with an eye-piece. The best amount of etching should be determined by experiment, noting how long the glass remains on the lead dish. Those not accustomed to hydrofluoric acid need warning that they should be very careful not to inhale any of it, or to allow the gas to come in contact with their person in any way. But with no more than ordinary care, and working out of doors as described above, there is no reason to fear trouble. The dish, after use, should be washed out with a copious supply of water before bringing it into the house.

Wratten's Panchromatic Plate.—Referring to my remarks on this last month, the makers inform me that it is a bathed plate. This therefore accounts for its especial properties.

The Committee of Bibliography, and of Astronomical Sciences, of the Royal Observatory of Belgium, has undertaken to publish a list of the observatories and astronomers of the whole world. A request for information, in the form of a list of questions, with a model reply relating to the Astronomical Service at the Uccle Observatory, Belgium, has been addressed to all the directors of observatories. In addition the list will include such astronomers (University professors, amateurs, &c.), who are not attached to any observatory, but are nevertheless actively engaged in astronomical research. The information already sent will enable the Committee to draw up not only a list of observatories, with their geographical co-ordinates and the members of the staff, but also a table showing the astronomical activity of the whole world, thanks to the facts given as to the instruments at the disposal of each institution, the pieces of research undertaken, and the papers published. We are asked to appeal to the directors of those observatories who have not received the question-form, or who have not yet forwarded a reply, as well as to unattached astronomers, and trust they will send the information desired, or to repair any omissions, as soon as possible, addressed to the Chairman of the Committee, Prof. P. Stroobant, astronomer at the Royal Observatory of Belgium, Uccle, Belgium.

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The New Planet TG.

By A. C. D. CROMMELIN.

THE zone of asteroids has certainly attracted more attention from astronomers since the discovery of Eros in 1898. There was a natural expectation that further sensational orbits might be discovered, and after a lapse of eight years this expectation has been realised. The planet TG is indeed of less practical importance than Eros, which has already proved so useful in measuring the Sun's distance, but its theoretical interest is nearly, if not quite, as high. The new planet is remarkable for its very large mean distance, which is practically identical with that of Jupiter; and as it has a considerable eccentricity, its aphelion lies far outside Jupiter's orbit, so that the family of asteroids, as now known, ranges from distance 1.1 (perihelion of Eros) to distance 6.1 (aphelion of TG). They have in fact burst their bounds in each direction, going far inside the orbit of Mars and far outside that of Jupiter. It is probable that the disturbing action of these two planets has brought Eros and TG into their present orbits. Herr Dziewulski, of Cracow, has recently published some researches on the motion of Eros, in which he takes account of the modification of its orbit produced by the action of the other planets, and finds that about B.C. 7,400 its orbit intersected that of Mars, so that very close approaches of the two planets would be likely to occur. It is, in fact, very probable that the orbit of Eros was deflected into its present position by such an encounter or series of encounters with Mars. Its orbit even now cannot be looked on as perfectly stable, for about A.D. 8,800 it will again intersect that of Mars, and further notable changes are likely to occur, whose exact character it is at present impossible to determine.

It would at first sight appear that TG was in still greater danger of destructive changes in its orbit than Eros, for its troublesome neighbour is not the small and feeble Mars, but the giant planet Jupiter, notorious for the mighty disturbances which he produces in the orbits of heavenly bodies so unfortunate as to pass near him. However, Professor C. V. L. Charlier (in *Astr. Nachrichten*, No. 4,094) indicates a possible way of escape for TG from such destructive changes, which will at the same time afford a most interesting illustration of a principle which had already been recognised as theoretically possible, although no actual case was known. The "Problem of Three Bodies" or the attempt to arrive at expressions which will give their mutual positions at any time we may desire, is probably insoluble in the general case, though the results of lunar and planetary theory have been arrived at thanks to the circumstance that in these cases one of the attracting bodies is greatly superior to the others in its action, and a solution by successive approximation is thus rendered possible. There are, however, a few simple cases where a rigorous solution of the problem has been arrived at. One is when the three bodies are in a straight line and also moving in that line. In this case elementary methods suffice for a solution (at least so long as no collision takes place; if such happens a knowledge of the elasticity of the bodies is required, before we can predict their subsequent behaviour). A more interesting case is the one which Dr. Charlier considers may very probably be exemplified by the Sun, Jupiter and TG. Lagrange showed that if three bodies are placed at the angles of an equilateral triangle and projected with appropriate speeds in the proper directions, they will continue to form an equilateral triangle unless disturbed by some extraneous force such as a fourth body, a resisting medium, etc. Dr. Charlier himself continued the investigation in "Publications of the Lund Observatory," No. 18, and showed that the system might still be stable, even if the triangle were not accurately equilateral to start with; we should in this case get oscillatory motion, never deviating very widely from the symmetrical form. There are two reasons for thinking that the three bodies named above form a system of this kind: (1) The period found for TG by Dr. Berberich (viz., 12.02 years) is almost exactly the same as that of Jupiter (11.86 years). As the planet has only been under observation for three months it is quite possible that Dr. Berberich's period is in error by this trifling amount (about two months), and that the periods are really exactly equal. We shall probably have to wait till next year before this point is certainly known. (2) The angle subtended at the Sun between Jupiter and TG does not differ greatly from 60°. It was in fact 55° 31′ on February 22 last, which is quite within the possible range of oscillation about a mean value of 60°.

Assuming that the period of TG is really 11.86 years, Dr. Charlier finds that its motion can be approximately pictured as follows: (1) Consider a point travelling in an ellipse about the Sun with the period 11.86 years, but with the perihelion point advancing so that the period from the perihelion passage to the next is 11.90 years. (2) Consider TG as moving in a small ellipse round this point in a period of 148 years. The size of the ellipse will be deducible when the elements of TG are better determined, but it may be large enough to produce a very noticeable shift in the position of TG. Dr. Charlier has considered the case of a small planet whose orbit plane coincides with that of Jupiter. The plane of TG deviates very notably from this, and there will, I suppose, be similar perturbations in latitude, viz., one with a period of about twelve years, which is practically the principal term in latitude, and another with a much longer period. Of course TG will be liable in addition to perturbations by the other planets, of which Saturn will play by far the greater *rôle*. These, however, will be of an oscillatory character, and will probably not tend to derange permanently the balance of the system. It is to be hoped that Dr Charlier's expectations may be verified, and that TG may indeed prove to exemplify a type of motion so wonderfully anticipated by the great Lagrange more than a century ago. To strengthen his case he states as a conjecture that Jupiter would probably compel a planet that had a period nearly the same as his to take up this exact period, since otherwise its motion would seem to be unstable. He makes the suggestion that the regions 60° distant from Jupiter on each side should be diligently swept for other bodies of the same type, and even extends the suggestion to the case of Saturn, though the prospects here are not very encouraging.

TG must be a fairly large asteroid; judging from its brightness its diameter can scarcely fall below 100 miles, which far exceeds the estimates for most of the recent discoveries. Professor Barnard deduced that Ceres headed the list with 480 miles, Vesta, although brighter, being only 240 miles in diameter. Dr. Berberich's elements follow; it will not be difficult with their aid to insert the orbit in a diagram of the Solar System.

Epoch, 1906, Feb. 22. Berlin. Midnight.

Mean Longitude	48° 57′
Longitude of Perihelion	76° 0′
,, ,, Asc. Node	315° 34′
Inclination to Ecliptic	10° 21′
Eccentricity	0·1676

Period 12·02 years.

Mean distance from Sun		5·248
Least	,,	,, 4·369
Greatest	,,	,, 6·127

Earthquake Areas.

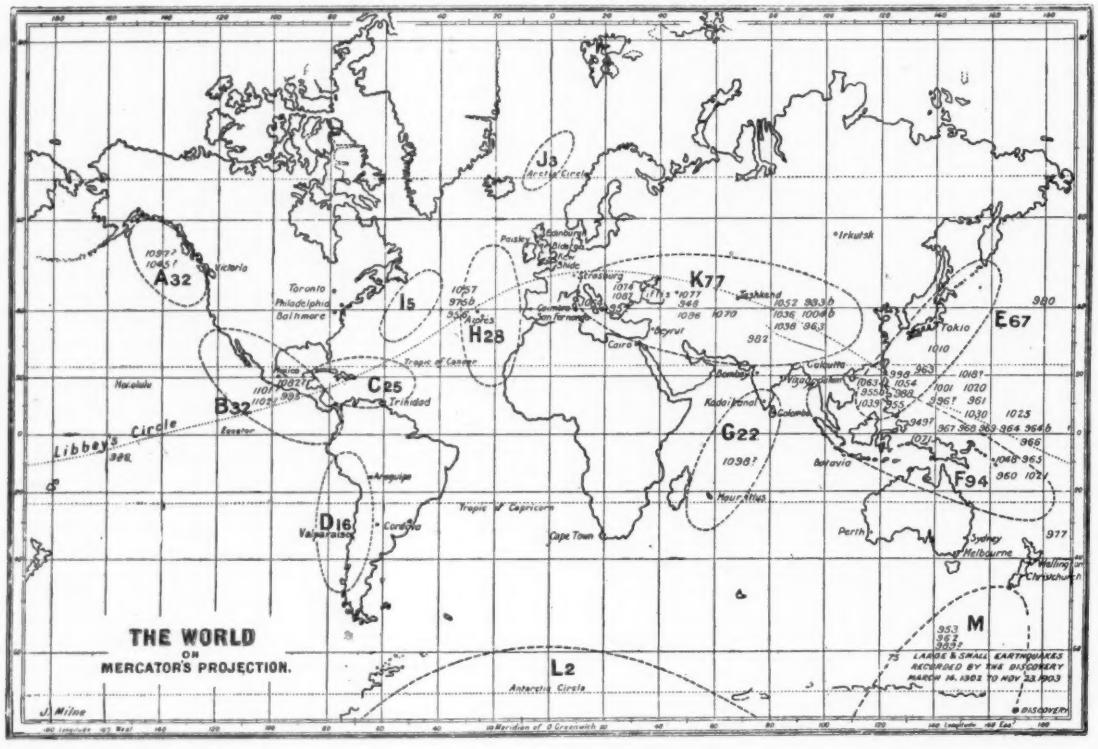
As students of seismology are well aware, the earth's surface contains many large areas where, owing to the distribution of pressure of the strata and the comparative instability of equilibrium among the strata, there is a continual liability to those movements of the earth which are called earthquakes. These areas have been mapped out by Professor John Milne and other observers, and a chart is annually presented to the British Association showing the number of earthquakes that have originated in these areas, and the records of which have been sent to Professor John Milne's observatory at Shide, Isle of Wight. In view of the tragic interest of the recent earthquake at Valparaiso, we reproduce this year's chart. Its details and its figures largely explain themselves, and it is only necessary to add in further explanation of them that the major earthquakes, such as arouse disturbances large enough to be recorded on the instruments in the larger number of the world's observatories, are recorded in large numerals, such as A32. The letters A, B, &c., refer merely to the earthquake areas, Andean, Cordillerean, Himalayan, Antillean, &c. It will be noted, as any intelligent observer would have suspected, that the larger number of earthquake areas are situated where there is a great range of mountains, and preferably where the mountain range is in proximity to a sea-board, so that the mountainous range slopes beyond the coast to the ocean floor. In such a case the actual perpendicular distance from the crest of the range to what we may figuratively call its foundations is much greater, and in speculating on the causes of earthquakes we may regard the upper strata on this great pile of stratified rocks as tending to slip over one another. We may further regard the tendency as accentuated by the fact that the lowermost strata, being under very great pressure, are approaching that condition when they tend to lose their solidity and become viscous. Laboratory experiments have shown that given sufficiently high pressure iron can be made to flow. We may presume that the lower rocks will flow also. Therefore, a great mountain range situated next to an ocean is not in stable equilibrium, and a movement sometimes of earth-shaking magnitude may be precipitated by very many apparently slight causes.

British Association, 75th Report, York, 1905.

Origins for 1905 are indicated by their B.A. Shide Register number. The number of earthquakes which since 1899 have originated from these is expressed in large numerals.

The Large Earthquakes of 1905.

Earthquake districts are indicated A, B, C, &c., and the Observing stations are named.



Among these causes tidal influences and synchronous solar disturbances have been suggested, but the most interesting suggestion made during the last few years has been one which relates to the figure of the earth, and to the movement of the earth's axis. The movements of the earth's axis are not uniform, and if a curve be plotted showing the path described by the earth's pole in its periodic cycle, it will be found that the path traced is not regular, but contains irregular and sudden alterations of the curve. Now if the earth were a spherical body all parts of the surafce which were in the same state of strain, it is conceivable that movements of this nature would not affect the stability of its crust. But it is evident that the crust of the earth is not of uniform stability, and it has lately been suggested by Sir G. H. Darwin and Mr. Jeans, of Cambridge, that the earth is not sphere-shaped, but shows traces in

its form of a period when it was pear-shaped. The waist of the pear would be its weakest region or line, and along this line any strain resulting from sudden disturbances of the earth's axis would be felt more severely than anywhere else. If the regions along this line of weakness had a predisposition or susceptibility to earthquake movement, then in a time of stress we should expect earthquakes to be manifest chiefly along this line. That, according to Professor Milne, is what we found last year. A glance at the map shows that of the 57 widespread earthquakes of last year, the great majority were confined to a circle passing from Central America through the Azores, the Alpine, Balkan, and Himalayan ranges into the East Indian Archipelago. The quiescence of districts which do not lie on this band was very marked during 1905, though it has now been sensationally interrupted by the Valparaiso earthquake. There was a destructive earthquake in Calabria on September 8, 1905, but Professor Milne is not sure whether it was in any way connected with the relief of volcanic stress which began as early as May, 1905, and culminated in the violent eruptions at Vesuvius in April, 1906. The largest earthquakes, eclipsing this, or the Indian one of April 4, 1905, or even that which on April 18 of this year devastated Central California, were two which occurred in Central Asia in July of last year. No accounts of destruction, however, reached England, so that the districts where they occurred must have been sparsely populated. One of them was felt at Tomsk, in Siberia.

Other observations in Professor Milne's report disclosed the interesting suggestion that on the west side of the Pacific earthquakes are more frequent in summer, while on the eastern side they are more frequent in winter. It is suggested that an explanation can be found in the seasonal alternation in the flow of ocean currents, the oscillation of sea level, and the changes in barometric gradients—phenomena which are all connected with one another. The most curious observations in the report are, however, as follows :—" It has been found that under certain but frequently recurring conditions the two opposite sides of a valley move in opposite directions at the same time. On bright, fine days the inclinations of the sides of a valley decrease. At night they increase. A valley may, therefore, be supposed to open and close. These conclusions, which do not necessarily apply to all valleys, are based on observations taken in two very different localities. The first were made in Tokyo, Japan, by means of horizontal pendulums giving continuous photographic records, installed on the two sides of a valley cut in alluvium. The phenomena may be due to the general warping of a district under the influence of solar radiation, or to the differential effects of loading and unloading of portions of the same. During the day the sides of a valley covered with vegetation lose load by evaporation and transpiration, and, therefore, underground drainage, tending to carry a water load to the bottom of a valley, is reduced. At night, with the cessation of these processes, the load at the bottom of a valley is increased. At that time streams and certain wells carry their greatest quantity of water. It is, therefore, at night that a valley may be expected to sag downwards, a suggestion that finds support in the observation that during wet weather, when we see streams in flood, the sides of the bounding valley approach each other in a marked manner. The conclusion is that as the world turns before the sun its surface is measurably smoothed, while at night the frecklings on its face are measurably increased."—E. S. G.

A Great Catalogue of Double Stars.

IT is only within the last two or three centuries that it has been recognised that there are such things as " Double Stars " ; that there are systems where two or more suns share the supreme control; unlike the case of our own system wherein our sun, lord paramount in its own family, exercises a single and undivided sway. The first star to be noted as double was Zeta Ursæ Majoris, the " Star of the Girdle," discovered to be double by the astronomer Riccioli about the middle of the seventeenth century. It is a curious coincidence that this same star had also the distinction of being the first to be photographed as double, and again its components were the first to show themselves to be spectroscopic doubles.

The first great worker on double stars was Sir William Herschel, a century and a half later than Riccioli. He observed and catalogued them, not for his interest in them as such, but because he hoped to employ them in finding the parallaxes of the fixed stars. Before his day instruments were neither sufficiently powerful nor sufficiently refined to render possible the delicate measurements needed in such an inquiry. But Herschel was himself a great instrument maker, and was, therefore, himself able to overcome much of the instrumental difficulty of the problem; the outstanding difficulties he proposed to avoid by contenting himself with determining, not the absolute parallax of a star, but its relative parallax as compared with one which was at an indefinitely greater distance from us. His plan, therefore, rested upon the assumption that where we have two stars apparently close together in the sky, the fainter star is really immensely more distant than the brighter, and is only seen near it because the two chance to be nearly in the same line of sight. His plan failed because the faint comparison stars, which he chose, proved in so many cases not to be far distant from the stars whose parallaxes he sought, but to be so close that they were strongly bound together by gravity and moved together through the universe. The result of his inquiry, however, was that he produced the first catalogue of double stars. Herschel's eminent successor in this class of observation was the Russian astronomer, Wilhelm Struve. He began his astronomical career in 1813, and in 1837 he published at St. Petersburg his great work, generally known as the " Mensuræ Micrometricæ," containing the positions of 2,640 double stars.

About a quarter of a century ago Mr. Thomas Lewis, the Superintendent of the Time Department of the Royal Observatory, Greenwich, began in his leisure time a study of this great catalogue of Struve's, collating all the measures of the objects contained in it which he could gather from every available source. The result of this study showed that many of Struve's pairs had been neglected by observers, and about twelve years ago, at Mr. Lewis's request, the Astronomer-Royal granted him facilities for having these objects measured by the great Grubb refractor of 28 inches aperture, belonging to the Royal Observatory, Greenwich. This enabled Mr. Lewis to complete his study

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of Struve's great catalogue, and on his work being submitted to the Royal Astronomical Society, the Council decided to publish it as one of their Memoirs. In this magnificent volume, 715 pages quarto, Mr. Lewis has brought together the original observations made by Struve, of each double star, the observations made on the same by various observers throughout the world up to the present time, and those made by himself and his co-workers at Greenwich. From these he has deduced the orbits in which the pairs move about each other, wherever the material available is sufficient for that purpose, adding, wherever possible, particulars as to their masses, sizes, colours, and spectra.

There is no nationality in science, and yet there is a legitimate source for gratification that so magnificent a Memoir has been brought out by an English astronomer; that the observations of the great English Observatory have contributed so much to its completeness; and that it is published by the great English astronomical society. For, as has already been mentioned, it was an Englishman who founded double star astronomy, and some of the most distinguished workers in the field in its early days were also Englishmen. Towards the end of the nineteenth century, however, this important department was falling into neglect amongst English observers; the present President of the Royal Astronomical Society, Mr. W. H. Maw, being one of the very few who were keeping up the traditions of the Herschels, father and son, of the Rev. W. Dawes, and other great names of the earlier part of the century. The appearance of this Memoir is a proof that the subject has not lost its interest to English astronomers of to-day, and that it is being followed up with an energy and a skill in no way inferior to those of the very best workers of earlier days.

And the Memoir will tend to develop further activity in this field, and to render that activity much more efficient. It will be a great help to the double star observer thus to be at once put in possession of the observational history of any given star, without the necessity for a long and arduous search through records; whilst he can here readily learn what stars have been fully observed and what have been neglected, and when it is needful that this or that binary should be specially watched. The Memoir is not only a record of past work; it will be an important basis for work in the future.

But Mr. Lewis's work has a significance quite apart from the presentation of details respecting the relative motions of certain close stars, and it affords a remarkable example of the way in which the various problems of astronomy are intermingled, the one with the other. At first sight it would appear most unlikely that the watch upon one member of a pair of stars as it slowly gravitates round the other, should afford any clue as to the general form of the stellar universe; yet, as Mr. Lewis has shown in his Introduction, this altogether unexpected information does come out from the present Memoir. This important result partly follows from the far-seeing and comprehensive character of Struve's original work, and partly from the simple but ingenious treatment to which Mr. Lewis has subjected the material at his disposal.

During the two years, February 11, 1825, to February 11, 1827, Struve examined 120,000 stars from the first to the eleventh magnitude, and found 3,112 double stars, whose distance apart did not exceed 32″. Several of these pairs were rejected from the final catalogue of 1837, the "Mensuræ Micrometricæ" and a few fresh ones were added, so that the 1837 catalogue contains 2,640 pairs. Now in the seventy years which separates us from the date of the "Mensuræ Micrometricæ," many of these objects show no clear evidence of relative motion; others as unmistakably are moving the one with respect to the other. Mr. Lewis, therefore, divides the items of the catalogue into two classes—pairs in which the members are relatively fixed, and pairs of which the members show a motion relative the one to the other.

Now if we examine the distribution of the stars of the catalogue, certain facts become apparent. First of all an examination of double stars in general—no distinction being made between fixed pairs and pairs with relative motion—shows that their distribution follows very closely the distribution of stars in general. But quite a different state of things prevails if we inquire as to the proportion which the fixed pairs bear to the relatively moving pairs in different parts of the sky. The natural expectation would be that the two classes would show the same general law of distribution, and hence that the ratio $\frac{F}{M}$ would be much the same from whatever region of the sky it was derived. As a matter of fact its value is about three times as great in one region of the heavens as it is in the opposite.

What can be the explanation of this curious and strongly marked relation? Mr. Lewis explains it as follows:—

> "There is a very simple cause which might alter the proportion between fixed and moving pairs in different parts of the sky.
>
> "Given a keen observer with an instrument of a certain power, and let him tabulate the stars which appear double or multiple in a systematic search, and suppose, for example, that he can find such a triple as Σ 2367, where
>
> A and B are separated 0″.4 and form a rapid binary;
>
> A and C are separated 14″.1 and are relatively fixed.
>
> "Now reduce the power of his instrument to one-third and he can no longer see B, since 1″.2 is the smallest separation he can perceive—he might elongate 0″.8 The pair AC becomes a double star with no relative motion. The same effect is obtained by retaining his original instrument and removing the triple to three times its former distance. The separating power of his telescope is 0″.4, but B's distance from A is now 0″.13, and C's is 4″.7, so that B is still invisible, and C a fairly near companion without relative motion.
>
> "Put in a different manner, my suggestion is:—
>
> "There is no apparent reason why distant stars should not have close companions endowed with orbital motion as frequently as those nearer to us, nor is there any known reason why double stars should not be evenly distributed in space. If we find this distribution is not uniform it may be that in certain regions the stars are, as a whole, more distant from us than in others. Granting this, the proportion of fixed pairs to pairs showing relative motion should be a function of the distance of the stars from us."

It will be remembered that some three years ago Dr. Alfred Russel Wallace brought out a most interesting book the purport of which was to show that the entire trend of modern astronomy proved that the solar system was in the centre of the entire visible universe. It is one of life's little ironies that at that very time Mr. Lewis's Memoir was ready for presentation to the Royal Astronomical Society, with his demonstration that the statistics of double stars appear to show that the stars around us form a universe very much the shape of an egg, and that we are not situated in the

centre, but are upon one of the minor axes, and on that axis are three times as far from one extremity as we are from the other. Mr. Lewis estimates the longest diameter of the egg as roughly equivalent to six hundred light-years, the smallest diameter to three hundred light-years. The average proper motion for pairs showing relative motion is three times that of pairs showing no relative motion.

This important result is far from being the only one which Mr. Lewis has deduced from his inquiry. There was a time when the observation of double stars would have been considered suitable enough for amateur astronomers, but quite beneath the dignity of a great Government Observatory; indeed, it is doubtful whether the earlier Astronomers-Royal would have consented to give the work a place upon the Greenwich programme, seeing that the original purpose of the Observatory was the determination of the exact positions of the stars and the following of the movements of the sun. moon, and planets. Yet even from the standpoint of the severest interpretation of the original warrant for the Royal Observatory, double star work in Mr. Lewis's hands has justified itself, since in not a few cases it has thrown light upon the observation of stars in the transit circle, interpreting and clearing away apparent discordances. On the other hand, in the case of some binaries, the transit circle observations have enabled a period to be carried back a considerable time before the star was recognised as double, so that the two distinct methods of observation have supplemented each other to an important extent.

Nor is this all. In several instances it has been possible for Mr. Lewis to combine the discussion of the meridian observations of the brighter component with the relative motion of the fainter companion as deduced from the micrometer measures, so as to gain an idea of the relative masses of the two stars. The eighteen cases with which he has been able to deal give some very remarkable results. In twelve out of the eighteen cases the fainter star has the greater mass; in three cases the masses are about equal, although the stars differ considerably in brightness; in three cases the fainter star has the smaller mass, but the predominance of the chief star in brightness is enormously out of proportion to its superiority in mass. "As a rule the apparent satellite is, in fact, the primary of the system." The table which Mr. Lewis gives of these eighteen stars is a most suggestive one, for it indicates that the mass of the fainter star is much more closely related to its colour, that is to say, to its spectrum, than it is to its stellar magnitude. Given a star of the solar type of spectrum with a companion purple or bluish in colour (and, therefore, naturally assumed to be of the Sirian type), and the latter is, generally speaking, of the greater mass, though much inferior to the solar star in brightness.

Of course, the number of stars as yet available for such treatment is far too small for any broad general conclusions to be based upon them, but the importance of Mr. Lewis's table from a theoretical point of view can hardly be exaggerated. The natural way of looking at stellar evolution is to assume that the star of greater mass will cool the more slowly, and consequently that, of the members of a pair, the heavier star must be the hotter; we also naturally assume that it must be the more luminous as well. Yet the results which Mr. Lewis has put before us, so far as they go, emphatically negative this reasoning. Then, again, as between stars of the solar and of the Sirian types, it has been usually assumed that the latter are intrinsically much the brighter of the two, but in the view of the facts here presented this assumption will in future have to be revised.

One of the early workers upon double stars, Sir James South, on the publication of Struve's great work in 1837, is reported to have exclaimed, "There is nothing left for me to do!" South had not learnt that good work does not preclude further work, but forms the best possible basis for it; and we see from Mr. Lewis's Memoir at once how great and how important has been the work which others have built upon the foundation which W. Struve laid so broadly and so well.

Liquid Air.

The Knudsen System.

SINCE liquid air was made some years ago, at great expense, in the laboratory, its possible applications in industry as well as in science have become increasingly evident, and at the same time new and improved methods of manufacture have steadily reduced its cost. The latest and cheapest of these methods of manufacture, which reduces the price of liquid air to a hundredth, perhaps a thousandth, part of that at which it stood a few years ago, is called the Knudsen system, an installation of which has just been opened in Church Road, Battersea, by Major B. Baden-Powell. Early methods of liquid air manufacture depended on what is known as the cascade system; that is to say, that continually decreasing temperatures were obtained by causing successive volatile liquids to boil at reduced pressures. Thus ethylene, which boils below the freezing point of water, will boil at a lower temperature when the pressure of the atmosphere is taken from its surface, and will help to produce a degree of cold sufficient to liquefy carbonic acid gas, while the normally low temperature of liquid carbonic acid can similarly be reduced by again reducing the atmospheric pressure. Thus, as in a cascade, the temperature grows lower and lower by successive falls. The alternative method, of which Knudsen's is a type, depends on the principle of the adiabatic expansion of gases. When a gas is compressed heat is produced; when a compressed gas is allowed to expand suddenly, cold is produced.

In the Knudsen system atmospheric air is first of all purified and freed from dust, and is then compressed in a three-stage air compressor. In the first low pressure cylinder it is compressed to 90 lbs. pressure, in the second intermediate to 550, and in the third high pressure cylinder the pressure is 2,500 to the square inch. The air is cooled between the stages of compression to the temperature of the cooling water. After the air has been freed from dust and compressed to 2,500 lbs. to the square inch, it then enters a moisture separator, which removes the moisture from the air, as well as the oil and other impurities which might have vaporised and passed over in the process of compression.

The air, still at a pressure of 2,500 lbs. to the square inch, passes next through a number of copper coils. Surrounding these coils cold air from the liquefier passes in the opposite direction and lowers their temperature sufficiently to freeze the traces of moisture on the inside of the coils, leaving absolutely pure dry air to be liquefied.

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The purified dry high pressure air then enters the outer coils (seven in number). It passes through the three outer ones first. At the bottom of the apparatus there is a receptacle connecting the three coils together with the four others; this receptacle serves the purpose of separating the carbonic acid gas. After the air has left the four coils, it enters at the top of the central part of the liquefier. Here the air compressed passes through a number of very fine copper tubes to the bottom, and to a number of high pressure expansion valves. By these the air is reduced from 2,500 lbs. per square inch to 125 lbs. to the square inch, with a consequent great reduction of temperature. Thence returning over the small tubes it cools the high pressure air in them to such an extent that the air liquefies partly in the tubes and partly in the expansion valves.

The air which does not liquefy on expansion then returns over the small copper tubes, which are enclosed in a large copper vessel and connected with a pipe at the top leading to the turbine, where the air under 125 lbs. pressure is again expanded as nearly as possible to atmospheric pressure. It is thus doing work in the turbine, and thereby cooling itself to a temperature many degrees greater than before entering the turbine under pressure.

This cooling reagent in the form of exhaust air from the turbine re-enters the liquefiers at the top of the apparatus, circulating in the opposite direction to the high pressure air within the coils. This highly-compressed air passes over the four copper coils, in a downward direction, and then returns in the upward direction over the three first large coils of the liquefier. Thence it circulates as previously explained over one of the two moisture separators, and then to the conduct pipe to the low pressure cylinder of the air compressor, together with the atmospheric air drawn from the dust separator. The power which is saved by expanding air in the turbine is utilised for operating a small air compressor, and the air is utilised for cooling the high pressure air.

ASTRONOMICAL.

By CHARLES P. BUTLER, A.R.C.Sc. (Lond.), F.R.P.S.

Prominences Observed during 1905—January 1 to June 30.

THE Director of the Kodaikanal Solar Physics Observatory in South India has recently issued a second list of prominences, from observations made during the first half of 1905. The present record is rendered more complete by the fact that the prominences photographed with the spectroheliograph have been indexed, in addition to those recorded visually. The two conditions, of course, represent conditions of matter of two distinctly separate elements, the prominences recorded visually in the C(Hα) line being due to hydrogen, while those recorded photographically in the H line are due to calcium. Very interesting and important discussions arise from the minute comparative examination of these two sets of observations, and it is stated that from fifteen months' observations it appears that near the time of sun-spot maximum the prominences, as seen in hydrogen, agree, as a rule, very closely in form with those photographed in calcium light. There are a few prominences seen in the hydrogen radiation which are not found on the photographs taken with calcium light, and there are a larger number photographed in calcium which have not been seen in hydrogen. It is expressly stated, however, that it cannot be assumed without much further examination that all those photographed but not seen were actually absent from the hydrogen radiation. In many cases it is probable that the bright background of sky covered with thin clouds prevented their detection visually. Again, while, in general, the calcium and hydrogen prominences agree closely, there are frequently very marked differences. The chief of these is that whereas the visually-observed hydrogen prominences consist very often of a network of fine jets or filaments, the calcium prominences show a more continuous structure.

Of considerable importance from a physical standpoint is the statement that spectroheliograms of the disc of the sun occasionally show prominences extending to a considerable distance *inside* the limb, either (1) as an area of *dark flocculi* or (2) as an area *less dark* than the surrounding area, thus indicating greater absorption.

The tables contain details of more than 2,000 prominences determined during the half-year, giving the time of observation (Madras Mean Time), latitude, position on limb, and height in seconds of arc, an appendix of remarks being added for notes of special phenomena.—*Kodaikanal Observatory Bulletin.* No. 5.

Sun-Spots of 1906.

In the August number of the *Observatory* Mr. E. W. Maunder starts an interesting experiment in the publication of advance astronomical data. It is well known that the Greenwich serial spot numbers are standard for many solar workers, but hitherto these have not been available until the complete measures and reductions had been made, generally some six months after the end of the current year. By permission of the Astronomer Royal Mr. Maunder has made a preliminary examination of the solar photographs as soon as the necessary supplemental negatives have arrived from India, and numbered the spot groups at once. In an accompanying table he gives such serial numbers for the spots from December 24, 1905, to March 27, 1906. Additional information includes the duration of the spot, date of passing central meridian, longitude and latitude, the two latter being estimations only. In making use of this information it is to be understood that, while the numbering of the groups is definitive, the other particulars relating to the groups have only been derived from a preliminary examination of the photographs, and may subsequently be modified when measured correctly. This information, however, will be widely welcomed by workers desiring to use these statistics in connection with other work.

New Iron Arc Wave Length Standards.

In consequence of a decision by the Solar Union at Oxford in September, 1905, recommending the establishment of a new system of reference standards of wave length, MM. Fabry and Buisson have undertaken the task, and their results for the region λ3600-6500 have recently been published. The source of light was the iron arc, produced between poles 8 mm. diameter by a current of 3-6 ampères at a pressure of 120 volts. Each line selected for standardisation has been compared directly with the green ray of mercury given by a Cooper-Hewitt mercury lamp, this green line having itself been rigorously compared with the standard lines of cadmium. All these new determinations have been made by photography. To eliminate any errors due to expansion of the interferential apparatus the mercury comparison was photographed both before and after the exposure to the iron arc. The number of rays measured and tabulated to three decimals (thousandths of a tenth metre) is 84, each having been determined several times on different plates. In the region near λ5800, where there is rather a large gap without iron lines, four lines of nickel have been included. The wave lengths given are based on those of Michelson and Benoit for the green and red lines of cadmium, and like them, are the values in air at 15° C. and 760 mm. pressure.—*Comptes Rendus* 143, p. 165.

New Form of Spectroheliograph.

Experiments with various forms of spectroheliograph have led Messrs. G. Millochau and M. Stefanik to design a new

apparatus, in which the chief feature is the attempt at eliminating friction and consequent distortion. A two-slit spectrograph, of any form, is mounted so as to move round a horizontal axis perpendicular to the plane containing the optical axis of the combination. The motion of the apparatus is produced by a Brashear clepsydra, mounted vertically. This is connected with the spectrograph by means of a bar with pointed extremities, which enter into two conical holes, one of which is on the spectrograph in the prolongation of the optical axis of the collimator, while the other is at the end of the piston rod of the clepsydra. The axis of rotation of the spectroheliograph must pass through the point of intersection of the axis of the collimator and that of the telescope of the spectrograph. The distances between this axis and the two slits should be in the ratio of the focal lengths of the collimator and telescope objectives. If a grating is employed (and the recent discovery by Hale of the existence of dark hydrogen flocculi has shown the advantage of the greater dispersion given by a grating spectrum) the second slit may be stationary, and placed in the axis of the telescope; the setting on the spectral line can then be accomplished by a slow rotation of the grating. At its two extremities the secondary slit is widened for the purpose of taking a photograph of a portion of the spectrum of the diffuse light of the sky, thereby providing a simple means of determining the exact radiation with which the monochromatic photograph is to be obtained. A photographic plate may be placed immediately behind the secondary slit, supported by the stationary base of the instrument (Hale's arrangement), or the image may be photographed with a separate camera (Braun's arrangement). In this latter case the image may be enlarged or otherwise at will. This form of spectroheliograph may be arranged to receive light from a siderostat or a coelostat, or it may be attached directly to an equatorial.—*Astrophysical Journal*, July, 1906.

Observations of the Zodiacal Light.

Mr. Maxwell Hall has been making minute observations of the zodiacal light for many years past at Kempshot, in Jamaica, and, in a recent communication to the *Monthly Weather Review*, he brings together most of the observations and discusses them. His first series of tables show the estimated breadth of the phenomenon at varying angular distances from the sun. In the hope of obtaining additional information he employed a spectroscope on the subject, but he says that no bright or dark lines could be detected; its spectrum—what there was of it—was continuous, and coincided with the brightest part of the solar spectrum, being for all practical purposes apparently identical with the spectrum of twilight. Further work with a specially designed spectroscope only confirmed the view that the zodiacal light was reflected light from the sun. Close examination of many measurements of the breadth indicated that instead of the light being bounded by straight lines from the horizon upward these boundaries were curved very perceptibly.

The author next groups the observed latitudes of the various parts of the glow with respect to their longitudes or distances from the first point of Aries. In the resulting table there is certainly a suggestive symmetry, and further inquiry shows that the zodiacal light does not follow the ecliptic as has long been supposed from casual observation, but that it closely follows the invariable plane of the solar system. This plane not only has a mathematical conception, but it may also be regarded as the original plane of the solar system, throughout which was scattered all the matter subsequently condensed into the sun and planets. Employing the more recently determined values of the masses of the planets, the value found for this invariable plane is—

Inclination to ecliptic ... 1° 35′ 2″
Longitude of ascending node 106° 52′ 37″ } (1900·0).

Tabulating now the latitudes of the zodiacal light with respect to this plane, they are seen to agree very closely except at longitude 238°; it is thought that the discordance here may be due to the brightness of the planet Venus interfering with the observations.

The observations made by Mr. Maunder in Egypt about the end of 1897 are discussed, showing the zodiacal light to be parallel to the invariable plane, but some 1½° to the north. This is a tendency common to observations at all northern stations, and a series of authentic observations at southern stations would probably prove most useful. In conclusion, the author expresses the opinion that the invariable plane still contains such a large quantity of meteoritic matter as to reflect back the light of the sun in the form usually seen; also that the "*gegenschein*" or counterglow, may be due to the "*full moon phase*" of these particles of matter, and that all the observed irregularities of light are due to the irregularities in the distribution of the matter.

Meteorology at High Altitudes.

Most of the information concerning the upper air has been obtained by means of automatic meteorological recorders attached to kites or balloons. On November 29, 1905, a kite sent up from the Prussian Aeronautic Observatory at Lindeberg attained the record altitude of 6,430 metres. The self-registering instruments carried by the kite showed that at that height the temperature was − 25°, the temperature at ground level being + 5°; the wind had a velocity of 25 metres per second, that at the surface of the earth being only 8 metres per second. Six kites were employed, having a total surface of 27 metres, the length of line paid out being 14,500 metres. —*Ciel et Terre*.

Astronomical Clocks.

The astronomical clock is so important an instrument of the observatory equipment that any radical improvement or alteration appears to deserve special notice. The chief drawback to the employment of a first-rate clock has naturally been the expense, but much of this difficulty has been eliminated by the new offer of Messrs. E. Dent and Co.—a guaranteed inexpensive observatory clock at practically one-quarter the cost of the type of instrument which has hitherto been only available to the larger institutions. The new clocks can be obtained with either 12-inch or 10-inch dials, are fitted with dead-beat escapement and wood-rod second pendulum, and may be rated to either solar or sidereal time. If desired, electric contacts can be fitted at a small additional cost for transit work. By the kindness of Messrs. Dent we have been able to examine the rate record of one of these clocks, checked every morning by the standard Greenwich signal, and the variations shown indicate a very satisfactory compensation.

BOTANICAL.

By G. MASSEE.

The Wild Flora of Kew Gardens.

QUITE recently a special number of the *Kew Bulletin* has been devoted to the wild Fauna and Flora of Kew Gardens. As would be expected, intensive cultivation has altered the general features of the ground, and habitats at one time suitable for wild plants have now disappeared. Flowering plants have suffered most in this respect, and out of the 422 species listed, many have now disappeared for ever. Among interesting mosses are *Amblystegium Kochii*, known only from one or two counties in England, *Fissidens crassipes* and *Hypnum elodes*. Liverworts are very poorly represented in the list, although they are known to have been more abundant years ago, but unfortunately no early records nor specimens are forthcoming. Lichens, as would be expected, on account of their impatience of pure air, have practically disappeared, only fifteen species being enumerated, and these are mostly sterile. The paucity of members of the above-mentioned groups is atoned for by the Fungi, which at the present day number 378 genera and quite 2,000 species. The richness of the Mycologic Flora of the Gardens far surpasses in point of numbers, as also in the variety of rare and interesting species, any other record for an equal area. The richness of the fungal flora will be more fully realised when it is remembered that the entire British Fungus Flora consists of 5,000 species, and that of Europe of 8,000 species. In the genus *Russala* 53 species have been noted during the last ten years, out of a total of 61 British species. The large size and brilliant colouring of most kinds belonging to this genus render them very conspicuous objects in the arboretum during late summer and early autumn. Fresh-water

algæ are present in considerable numbers, and the list could probably be considerably augmented if special attention was paid to those microscopic forms occurring on damp walls warm water tanks, etc.

Welwitschia mirabilis.

This remarkable plant, one of the wonders of the vegetable kingdom, was discovered by Welwitsch in West Tropical Africa. The plant has a short obconic trunk mostly buried in sand; in old plants the trunk measures three to four feet in diameter at the crown. The two seed leaves or cotyledons are persistent, and in old plants are six to nine feet long; no other leaves are produced. Quite recently Professor Pearson has studied this plant in its native habitat, and added considerably to our knowledge of its habit and structure. The plant grows in desert regions and a portion of the water necessary for its growth is derived from the dense night-fogs prevalent, but the main supply is furnished by the very long root tapping subterranean water. When several plants grow close together natural grafts of a very remarkable appearance are often formed. The plant is dicœcious and pollination is partly, if not entirely, due to insects. The maximum age attained by individual plants is probably much greater than a century. *Welwitschia* belongs to the ancient group of Gymnosperms, and microscopic structure indicates affinity with the genera *Gnetum* and *Ephedra*. The details are contained in *Phil. Tran. Roy. Soc.*, 198.

Dry Farming.

Under this heading Mr. Cowan indicates in the *Century Magazine* the methods by which remunerative farming can be followed in regions where the rainfall is insufficient for the successful cultivation of ordinary crops by the usual farming methods. It has been amply demonstrated that wherever the annual average rainfall amounts to twelve inches, as good crops can be raised without irrigation as with it. The Campbell system of dry farming, named after the pioneer "dry farmer" of arid America, consists of a scientific method of soil culture and is based on the movements of water in the soil by capillary attraction. The underlying principles are two in number, and are as follows. "First, keep the surface of the land under cultivation loose and finely pulverised. This forms a soil mulch that permits the rains and melting snows to percolate readily through to the compacted soil beneath, and that at the same time prevents the moisture stored in the ground from being brought to the surface by capillary attraction, to be absorbed by the hot, dry air. The second is to keep the subsoil finely pulverised and firmly compacted, increasing its water-holding capacity and its capillary attraction, and placing it in the best possible physical condition for the germination of seed and the development of plant roots." If the method indicated is thoroughly carried out a rainfall of twelve inches is effectively preserved, and produces better crops than in those places that have an annual rainfall of twenty-four inches, and the farming is conducted on old lines. In opening up a new district the land is first deeply ploughed, behind the plough follows a special implement called a subsoil packer; the surface is then harrowed and pulverised. A year should elapse before a crop is planted, this amount of time being required for the collecting and storing of water by the compact sub-soil. The surface is harrowed and pulverised after each rainfall, but not at any other time. When the seed is sown the land is still harrowed after each rainfall until the crop is too far advanced to admit of this process without injury. Immediately after the crop is harvested the land is ploughed, followed by the sub-soil packer, and harrowed after every rain until the time for sowing arrives. Although the method evolved from the enterprise of private individuals, the United States Department of Agriculture has now undertaken the work of demonstration in new districts, and affords facilities for those interested in the matter. The development of this method of farming is of primary importance to the United States, where almost exactly one half of the area of the country has insufficient rainfall for the cultivation of crops by the ordinary methods of farming. All the ordinary cereals, forage plants, fruits, etc., can be grown by the method of "dry farming."

European Plants in the Tropics.

It has been recorded by Lock (*Ann. Roy. Bot. Gard. Peradeniya*) that when European plants are introduced into Ceylon, the changes in habit and other respects that they undergo, appear during the first year, and are permanent. There is no gradual accommodation to changed environment as might have been expected.

CHEMICAL.

By C. AINSWORTH MITCHELL, B.A. (Oxon.), F.I.C.

The Absorption of Odours by Milk.

IT is well known that milk has the power of absorbing with great rapidity traces of odorous substances with which it may chance to come in contact. Thus milk that has been exposed for some time in the cow-shed or in the shop may acquire a disagreeable flavour, and even the food given to the cows has not infrequently an influence upon their milk. Experiments to determine the speed of the absorption have recently been carried out by MM. Bordas and Toutplain, who selected formaldehyde as the odorous substance, partly because it can never be a normal constituent of milk, and partly because it can be detected when only present in the faintest traces. They found that milk exposed for about one minute to air containing formaldehyde vapour had absorbed an appreciable amount, and that even when the proportion of formaldehyde in the air was only one in 100,000, an unmistakable reaction was obtained after a few minutes' exposure. So rapid is the absorption that a reaction was given by milk that had been placed in a vessel which had contained a dilute solution of formaldehyde and had subsequently been carefully rinsed with water. The rate of absorption of the vapour appears to decrease as the milk becomes older. It is suggested that this property of milk might be utilised in testing air for traces of formaldehyde.

The Preparation of Hydrogen from Calcium Hydride.

It has been shown by M. Moissan that when metallic calcium in a fine state of division is heated in hydrogen it absorbs a molecule of the gas, to form calcium hydride, CaH_2, a compound which is decomposed on contact with water giving off hydrogen, just as acetylene is liberated under similar conditions from calcium carbide. The manufacture of the hydride as a commercial product has thus two stages, viz., the production of the metal calcium by the electrolysis of fused calcium chloride, and the conversion of the metal into hydride by heating it in horizontal retorts through which is passed a current of hydrogen. The commercial substance is in the form of irregular grey or white lumps, which are very hard, and do not dissolve in the ordinary solvents. They are termed *hydroliths* by M. Jaubert, who also calls attention to their value for military ballooning. They contain about 90 per cent. of pure calcium hydride and yield about one cubic metre of hydrogen per kilo. on treatment with water. They have already been used with success for the initial inflation of balloons, and for the introduction of more gas without risk and without bringing the balloon to earth.

Artificial Silk.

A solution of cupric oxide in ammonia readily dissolves paper and other forms of cellulose, and the dissolved substance can then be re-precipitated by the addition of acids or other substances. This forms the basis of several processes for the manufacture of artificial silk including that embodied in two recent French patents, in which the cellulose is re-precipitated by means of an alkali hydroxide in the form of fine threads, which are washed and freed from ammonia by exposure to a current of air and treatment with a dilute acid. It is claimed that the artificial silk threads thus obtained are perfectly transparent, that they have a very brilliant lustre, and that they are stronger than those produced by other processes. The effect of the alkali upon the cellulose appears to be similar to the change produced in cotton in the so-called "mercerising" process.

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Volcanic Carbon Dioxide.

The liberation of carbon dioxide from numerous vents is apparently the final manifestation of volcanic activity in the district of Auvergne. All the mineral springs in the neighbourhood are heavily charged with the gas, and one of those at Montpensier, which issues in a large crevice, has long been known as the "poisoned well." Animals that take refuge in the crevice or come to drink the water are rapidly asphyxiated by the gas, which is always accumulating there. The bodies of birds, rabbits, dogs and sheep are frequently found in this crevice, and many children have lost their lives in the same way. Hitherto, this was the only spring of the kind known, but recently it was noticed that the vegetation to the North-East was discoloured by stains, and these were found to be due to the plants being poisoned by carbon dioxide liberated at these points. Acting on the advice of M. Glangeaud the owner of the land subsequently discovered several places where the gas was being emitted from fissures in the rocks. Two springs were also found in crevices several yards in depth, and these crevices were particularly interesting from the fact that they contained Roman pottery, and the skeletons of oxen, sheep, horses, and a man, and at a lower depth the skeletons of a mammoth and a bison (*Bos priscus*). All of these had apparently been asphyxiated by the gas in the same way as the animals of to-day. Some years ago, it was pointed out that thousands of litres of carbon dioxide were being lost daily in Auvergne, and that it would be profitable to collect and liquefy the gas. This, it was shown, could be done very cheaply and the product would be much purer than the ordinary commercial liquid carbon dioxide, which might contain poisonous impurities such as carbonic oxide, whereas the natural gas contained only carbon dioxide and nitrogen. Liquid carbon dioxide has been prepared for some time past in the volcanic districts of Eifel and Westphalia, and now a start has also been made at Montpensier. The actual amount of gas at present liberated is about 500,000 litres per day, but a much larger quantity could be collected by means of suitable borings.

GEOLOGICAL.

By EDWARD A. MARTIN, F.G.S.

Destruction of Valparaiso by Earthquake.

THE news to hand of an earthquake at Valparaiso and the surrounding parts of Chili continues the extraordinary earthquake and volcanic history of this remarkable year. Full details are not yet to hand, but the country is well known as being liable to such disturbances. The shock reached Professor Milne's instruments in the Isle of Wight soon after midnight of August 16-17, after travelling 6,000 miles, and that authority is reported to have stated that a movement of earth was perceptible for more than five hours, the actual time of the greatest shock being 7.15 p.m. on August 16. The city of Valparaiso was concerned in the great earthquake of November 19, 1822, when the shock was felt simultaneously over a space of 1,200 miles of Chilian coast. At Valparaiso the coast was elevated three feet, a part of the bed of the sea being exposed, the rocks being covered with dead oysters, mussels, and other molluscs. Great fissures showed themselves, this being a phenomenon particularly noticeable in South American earthquakes. Some of the fissures in the granite extended a mile and a half inland from the coast. The whole of the Chilian coast was raised from three to four feet, and sand and mud-cones a few feet high were opened up in numerous places. It will be well to note whether similar phenomena have now been exhibited.

Chalcedony in the Antrim Basalts.

The occurrence and origin of the Carnmoney chalcedony has recently been described by Mr. James Strachan. The chalcedony occurs in large cracks or veins in the lower basalts of Antrim. These are sometimes as much as 12 inches in width, and from this the cavities thin away into a mere hair's-breadth. These veins have apparently been formed during the consolidation of the lava, for the veinsides are coated in all degrees of thickness from a mere film to one inch, with the mineral *hullite*, which has been described by Professor Cole as "the altered and hydrated glass of the original basaltic ground-mass." Carnmoney Hill, with its steep escarpment sloping sharply towards the Belfast Lough, is a prominent and picturesque feature in the landscape of the country lying to the north of Belfast. The attention of the geologist is attracted both by the peculiar shape and the comparatively isolated position of this hill, which represents the site of an ancient volcano, from whose throat, in Tertiary times, poured forth part of the Upper Basaltic Lava. On the south side of the hill the denuded "neck" or "plug" of this old volcano may be traced, cutting through the Lower Basalt, the Cretaceous, and older strata. The Upper Basalt and part of the Lower have been removed by denudation, leaving the plugged-up vent, which is almost one-quarter of a mile in diameter. The material of the neck is a vesicular lava similar in appearance to that of the doleritic dykes found in various parts of Co. Antrim.

When Sea-Erosion Commenced.

The subject of sea-erosion of our coasts was again dealt with by the British Association at its recent meeting at York, and Mr. Clement Reid, the reader of the paper, is well able to deal with the subject exhaustively. I must confess, however, to a feeling of doubt as to the advisability of attributing the commencement of the erosion of our cliffs to a time so recent as from three to four thousand years ago. I think that such an estimate is liable to misconception, but I admit that may have been near the time when the sea resumed its position at the foot of the cliffs. But the cliffs then showing owed their existence to erosion in earlier times, although in the meantime, according to the interpretation of most modern geologists, the sea had retired, owing to an upheaval of the whole plateau on which the British Isles stand. When the sea again swept down the plain of the North Sea and reached the old cliffs which it had in a former age carved out of the land, then, of course, cliff-erosion again commenced, and this may have been as recent as the time estimated by Mr. Clement Reid. In this way a convenient starting point may be made, so far as modern erosion is concerned.

The Mediterranean Sea as a Lake.

The pigmy hippopotamus from Cyprus, whose skeleton has just recently been set up in the Natural History Museum, may, with the pigmy elephant of Malta, be regarded as the dwarfed representatives of normal races which formerly peopled tracts of land now covered by the Mediterranean Sea. Their existence brings to mind an ancient era when the Mediterranean was a land-locked sea, before the Straits of Gibraltar existed, and when, possibly, the various islands of the sea had a land connection, either with the mainland or an isthmus which connected Italy and Sicily with the African shores. A rise of the sea bottom of about 220 fathoms would cut off the connection with the Atlantic Ocean, and as a considerable portion of the shoreline of the Mediterranean would undoubtedly share in such an uprise, the area of the sea would become diminished, the new shores being a series of flat sandy steppes such as are found around the inland lakes of Central Asia. The loss by evaporation would still be as great as ever, and the Black Sea would be drawn upon to supply some of the loss, and would, in consequence, also suffer in area in the course of time, even if its shores did not share in the uprise. The subsidence which brought about the Straits of Gibraltar was apparently, however, not experienced so far east, or the Black Sea waters might have become connected with the Central Asian lakes. It is extremely probable that this connection did once exist, and subsequently the level of the Caspian has been so altered by the excessive evaporation which takes place upon its surface, that it is now 108 feet below the level of the Black Sea. The sinking down of the stretch of low sandy country which lies between the Sea of Azov and the Caspian to a comparatively slight extent would bring about a connection between their waters, and the Black Sea would pour its waters into the Caspian, and if the movement of subsidence were general, the sea would reach the salt lake of Aral, and much of Turkestan and

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Central Asia would be overwhelmed by the sea. So far as the races of mankind are concerned this might prove of immense benefit, and those whose ingenuity has suggested the flooding of the Sahara might turn their attention with greater benefit to this part of the Czar's dominions. So long as the Straits of Gibraltar remained open, a constant current would pour down from the Atlantic, and many of the salt steppes of Asia would be inundated. The subject is an interesting one for speculation, and one may well remember that what has been in past geological times is quite possible of repetition.

ORNITHOLOGICAL.

By W. P. PYCRAFT, A.L.S., F.Z.S., M.B.O.U., &c.

The Breeding of Humming Birds.

MR. COLLINGWOOD INGRAM, in the August number of the *Avicultural Magazine*, gives a most interesting account of the breeding of two species of humming birds in Trinidad—*Trochilus colubris* and *Florisuga atra*. His remarks, however, are mainly confined to a pair which had built on the bracket of a lamp hanging over the door of Lady Northcote's residence. Though the lamp contained a powerful electric light which was frequently turned on during the night so as to shine full into the nest, the birds yet elected to stay, although when sitting the hen was but a few inches from the globe! The more easily to keep a watch on the progress of the family a mirror was arranged over the lamp.

From Lady Northcote's notes it would appear that incubation took at least seventeen days, instead of the normal ten or twelve. This extended period is, probably, as Mr. Ingram suggests, due to the many alarms which the bird suffered when sitting.

Breeding of Rheas in the Zoological Gardens.

Once again the Rheas in the gardens of the Zoological Society have brought off nestlings; and all who are interested in the problems of the coloration of nestlings should take the first opportunity of inspecting these youngsters.

Unfortunately they cannot be compared, side by side, with the young of Darwin's Rhea, for the nestlings of these two species differ very markedly, the latter being very conspicuously striped, having a longer and more silky down, and a dull grey median stripe along the underside of the body.

Gadwall Breeding in Scotland

Mr. H. B. Marshall, in the *Field*, July 28, records the fact that a pair of Gadwall have succeeded in bringing off a brood in a small lake at Broughton, Peeblesshire—the first record of such an occurrence in Scotland, where the Gadwall hitherto has occurred only as a winter visitor.

Pelican and Spoonbill in Norfolk.

Mr. J. H. Gurney writes to the *Field*, August 4, to say that a Pelican was seen on Breydon Water, Great Yarmouth, by Mr. Arthur Paterson, a well known and experienced naturalist. About four hours after its arrival it was joined by a Spoonbill. The Pelican stayed till the next day, when, early in the morning it made off in the direction of the sea. Another Spoonbill, by the way, appears to have been seen on Breydon Water on April 28 of this year.

Though Mr. Gurney thinks the visit of this Pelican may be that of a wild bird, he suggests that it may also have escaped from some private collection. But the loss of such a bird should soon be known.

Rare Variety of the Jackdaw.

A rare variety of the Jackdaw is described in the *Field*, July 28, by Mr. H. Beveridge, of Sprouston, N.B. This bird, which he shot on July 15, had the head bright chestnut; neck, light buff; back and breast, bright chestnut, the back slightly mottled with black. The wing and tail feathers had a bronze sheen, but were otherwise black. "He is an old cock bird," he remarks, "in full plumage, and in every other detail is exactly like other Jackdaws. One thing I noticed, whenever he approached his neighbours they invariably hunted him away."

PHYSICAL.

By ALFRED W. PORTER, B.Sc.

The Radiation from a Welsbach Mantle.

ONE of the most interesting if perhaps not the most popular discussions at the recent British Association meeting was on the above subject. It was led off by a spirited challenging paper by Mr. J. Swinburne (who was unfortunately absent), in which a sketch was given of the various suggestions which have been made from time to time to explain the high efficiency of a Welsbach mantle, and the arguments for or against them were outlined. Dr. H. Rubens, of Charlottenburg (whose recent experiments have already been sketched in these columns), followed with an account of his experiments, and also of a demonstration of one of them. Light from an electric lantern is focussed on a cold Welsbach mantle so as to brilliantly illuminate it, and the reflected light is then focussed on a screen, where it forms an image of the mantle. A cell containing copper sulphate solution is interposed so as to isolate the blue rays. If now the mantle be made luminous by means of gas from the burner in the usual way, the reflected image on the screen is much less bright than before, instead of being brighter as might have been expected. The explanation is that at the higher temperature the mantle is a much worse reflector for blue rays than when cold. When a red cell is interposed, the effect on the screen is a little greater when the mantle is hot than when it is cold. When the mantle is cold, its reflecting power is comparatively large, and hence its radiating power is small for blue light. It is by no means a full radiator for such light. But when the mantle is heated its reflecting power diminishes; its radiating power for blue rays must therefore increase. This effect is not obtained for red light, and by inference we may suppose that for infra-red radiation there is no increase of radiating power when the mantle is hot. The bearing of the experiment on the behaviour of a Welsbach mantle is obvious. Such a mantle is nearly white when cold; this being so, we might expect it to be a poor radiator of all kinds of radiation; it is from a black body that most radiation is expected; so much so that the perfect radiator is usually (though rather curiously) known as "a perfectly black body." But radiating power for the more luminous radiations increases with temperature; hence at any high temperature the proportional amount of luminous radiation is greater than at any low temperature. Thus the mantle remains at high temperatures a bad radiator for most radiations, and is therefore able to reach a high temperature when immersed in a flame. Its great luminous efficiency is to be traced, therefore, to the combined action of this high temperature and the increased radiating power for luminous radiations. In the discussion which followed, there appeared to be a diversity of opinion as to what Dr. Rubens' experiments proved. One speaker congratulated Dr. Rubens on having demolished Mr. Swinburne's contentions; another considered that Rubens and Swinburne were in practical agreement (although Swinburne did not lay enough emphasis on the existence of selective radiation). With the latter opinion Dr. Rubens concurred. The outcome of the discussion is to show that to account for the efficiency of the mantle, there is no need to invoke the operation of chemical changes or phosphorescence. Dr. Rubens, when questioned, was not disposed to deny the presence of such additional phenomena. They may be present even in the case of a thoria-ceria mantle, with which his experiments were mainly concerned; in the case of others they may be present to a greater degree. But he considered the evidence wholly against attributing the main phenomena to these causes. The difference between the opposing views may be brought out by indicating that according to the temperature explanation, the total radiation from the thoria and ceria is equal to the sum of the radiations *at the actual temperature of the mantle* which would be emitted by the separate thoria and ceria *at the same temperature;* while on the chemical hypothesis a radiation appears as the result of combining the thoria and ceria which would not be present if these materials were separate.

The discussion, which was of a somewhat recondite

character, was enlivened owing to Mr. Swinburne having sent replies to possible speakers. These were read, and, being in Mr. Swinburne's characteristic style, they helped to relieve the tension.

Is an Alpha Particle Initially Uncharged?

This question was the subject of a paper at the British Association by Mr. F. Soddy. Several attempts have been made previously to give a satisfactory answer to it. When an Alpha particle is ejected from radium emanation, does it go away charged or is it at first uncharged, acquiring a positive charge afterwards by impact with the particles of air which it ionises? It is certainly a most fundamental question, because our views of the ultimate constitution of matter are likely to be very different according to the character of answer given to it. Tremendous difficulties meet the experimentalist in endeavouring to discover the real state of things. It is essential that the Alpha particles tested should have had no chance of colliding with other matter before the test is made. This involves that they shall be allowed to move only in the highest attainable vacuum, and also that they shall be emitted from a radio-active substance which is not more than one molecule thick. The latter condition can be satisfied by dealing only with the decomposition of radium C, which can be deposited in a calculable amount upon the walls of a vessel. But the attainment of a sufficiently high vacuum presents enormous difficulties. In an ordinary Röntgen ray vacuum, there are probably still something like one hundred millions of millions of molecules in every cubic centimetre, and even if the vacuum can be pushed one hundred million times further, there are still one million such particles present; so that an Alpha particle penetrating through one centimetre length of such a "vacuum" would encounter one hundred molecules. Mr. Soddy considers that he has sufficiently overcome this difficulty. The test of charge employed by him is the magnetic deviation of the Alpha stream. Conditions were arranged so that the stream was completely deviated under ordinary conditions and, with the magnetic field excited, did not succeed in escaping from the capillary tube in which the active deposit of radium C had been laid; and the experiment consisted in testing whether any deviation (arising from the supposed charge of the stream) took place when the vacuum was made as high as possible. Long series of results, all of which indicated possession of a positive charge, led to successive improvements of the conditions; and, in the end, such conditions were obtained that the stream *underwent no deviation*. The requisite condition for obtaining this result seemed to be that the emanation should be left for as short a time as possible in contact with the glass, which it gradually modifies, producing a black deposit in it. If this result is accepted as unequivocal, the conclusion necessary is that the Alpha particle is initially uncharged. Mr. Soddy himself does not seem quite confident in his explanation of the repeated failures, and until any such doubt is cleared away it is premature to make any revolutionary change in our conception of what goes on in radio-active changes. There are undoubtedly difficulties in either view. The great difficulty in considering the charge as being possessed from the beginning of the isolated life of the Alpha particle, is that not only would the particle take away a positive charge, but in many cases it also leaves behind a positive charge. Now the simultaneous production of equal amounts of positive and negative electricity would seem to be as necessary as the simultaneous production of two ends to a string in cutting it. Many of us had thought that this difficulty had been completely removed in the fairly recent discovery of slow moving negatively charged emissions (already referred to in these columns). It is well known that the characteristic electric phenomena of radio-active change do not take place unless the particles discharged have a velocity higher than a certain critical one. Any amount of discharge of negative electrons may, therefore, be taking place without any sign of it being detectable by our electrical instruments. If the positive Alpha particle leaves behind a positive substance which simultaneously emits slow moving negative electrons (corresponding in some respects to the slow moving gases which are ejected from a Roman Candle at the same time as the ball), the fundamental laws of classical electricity will be satisfied. A similar explanation may of course be made to account for the positive charge of the residue, even if the Alpha particle goes away uncharged. But in this case we have to account for the subsequent production of a positive charge. If it acquires it from a gas molecule which it ionises, the negative that remains must not be forgotten; any region completely through which a flight of positive charges has taken place will be left negatively charged, though to an amount which is at present too small to be detected. The writer believes that Mr. Soddy is of opinion that his views are about to lead to an overthrow of the fundamental laws of electricity. Mr. Soddy has, on another occasion, suggested as much. The present writer would urge all who are thinking about this subject never to forget that it has been definitely shown experimentally that in the sum total of radio-active charges which occur inside a closed space, the total amount of electrification produced is zero.

ZOOLOGICAL.

By R. LYDEKKER.

The Sleep of Animals.

SINCE there is very little of general interest to record in the matter of pure zoology, I venture to devote my first two paragraphs to subjects properly coming under the designation of physiology. Sleep is an attribute common to all the more highly organised terrestrial animals (although whether whales and dolphins ever slumber is still unknown); and there are quite a number of mammals which become torpid for a longer or shorter period, either during the drought and heat of a tropical summer, or in the cold weather of the northern winter. As regards the cause of that suspension of consciousness which we call sleep, recent investigations indicate the probability of the existence in the brain of a "break-and-make" action. When the whole apparatus in connected, the brain is in full working order; when the disconnection is made, sleep is the probable result. The active working power of the brain lies in certain nerve-cells; from these spring nerve-cords, which in their turn divide and sub-divide till they terminate in small knobs Formerly these nerve-cells were supposed to be in permanent connection by means of their terminal branches; but now it appears that the terminations of these branches are only in apposition, and are capable of being separated. The fact that narcotic substances induce it is an almost convincing proof that such separation is the immediate cause of slumber. It is added by Sir William Gowers, who has lately developed and explained the new theory, that by its means we are readily able to explain the phenomenon of sleep-walking.

Fish Out of Water.

It is well known that certain kinds of fishes are able to live out of water much longer than others; the power being dependent upon the length of time that their gills are capable of remaining damp. So long as this condition lasts, fish are able to obtain the necessary amount of oxygen from the air through the medium of the water spread over the fine membrane of the gills. Recently a German has invented an apparatus by means of which the gills can be kept moist for an indefinite period. This apparatus consists of a wooden box, with a number of compartments corresponding with the size of the fishes. On the floor of each compartment is a layer, half an inch deep, of cloths saturated with water, which by evaporation keeps the atmosphere moist. The gills of the fishes are thus kept damp; while oxygen is supplied from a receptacle outside the box. Many kinds of fresh-water fish have, it is said, been kept alive for from three to four days, by means of this ingenious invention.

The Fossil Reptiles of Africa.

The extinct reptiles of South Africa are among the most wonderful in the whole world, and have attracted the attention and interest of a number of the most distinguished palæontologists; and well they may, seeing that they include among them the undoubted ancestors of mammals, although this ancestral group is by no means confined to

the great southern continent of the Old World. One of the latest workers on this fauna is Dr. R. Broom, Professor of Geology and Zoology at the Victoria College, Stellenbosch, who has lately published a paper on these reptiles under the serial heading of *Science in South Africa*. All who are interested in a very interesting subject should make a point of consulting this excellent little *résumé*.

Freshwater Faunas.

As was remarked, in connection with the "Broads," in the last presidential address to the Norfolk and Norwich Naturalists' Society, much work remains to be done before we can consider our knowledge of the inhabitants of even our own freshwaters in anything like a complete or satisfactory condition. If this be the case with the freshwaters of Great Britain it is, *a fortiori*, much more so with those of the tropics. Naturalists should therefore be pleased to learn that Dr. Nelson Annandale, Deputy Superintendent of the Indian Museum, Calcutta, has commenced a systematic investigation of the freshwater faunas of India, the results of which are in course of publication in the Journal of the Asiatic Society of Bengal. Although only seven parts of this memoir have appeared—and these very short ones—Dr. Annandale has already been enabled to record certain discoveries of very considerable interest. He has, for example, obtained an aquatic cockroach (*Epilampra*), belonging to a group previously known only from the Malay States and Borneo. More interesting still is the discovery of an aquatic weevil, since no representative of this group of beetles with habits of this nature has hitherto been known. This weevil, which is not even generically identified, feeds upon a particular kind of water-plant; and Dr. Annandale has fortunately been able to describe its complete life-history.

British Biting Flies.

In connection with insects, reference may be made to the publication by the British Museum of a beautifully illustrated monograph of the blood-sucking flies to be met with in the British Islands; mosquitoes and gnats, as well as horse-flies, etc., being included in the work. The feature of the work (for the text of which, Mr. E. A. Austen is responsible) is the enlarged coloured figures of a considerable proportion of the species.

CORRESPONDENCE.

To the Editors of "KNOWLEDGE & SCIENTIFIC NEWS."

DEAR SIRS,—In your current issue Mr. Porter draws attention to the fact that an image may, under certain circumstances, be seen by converging light reflected from a concave mirror. This is interesting, but the instance is not by any means an isolated one. The image may also be seen with an ordinary convex lens, which is, of course, theoretically similar to a concave mirror. To observe this, place a lighted candle behind the lens at a distance greater than the focal length, and view from a point between the lens and the real image of the candle. The observed image is erect, and is still visible when the eye is drawn close up to the lens. It is, in fact, nothing more or less than the ordinary image seen by all persons who wear convex spectacles.

The mirror phenomenon is brought into line with text-book optics if we regard the mirror and the lens of the eye as together forming an optical instrument which throws a real image of the candle on the retina.

Yours truly,

Sheffield University, August 16, 1906. LEONARD SOUTHERNS (Whit. Schol.).

[The image referred to must, of course, be obtainable from any optical system producing a real image by means of rays of small convergence. The comparison with the ordinary use of spectacles is, I think, rather misleading. Convex spectacles for distant vision are employed when the wearer is able to focus *only converging* pencils. One object of my note was to indicate that the power of forming a tolerable image by means of converging pencils is common to those who are not really long sighted. For example, I am quite unable to accurately focus the stars, but images formed as above are tolerably good. I do not concur in the last paragraph of Mr. Southerns' letter, because it fails to recognise that the images are *usually* imperfect.—A.W.P.]

REVIEWS OF BOOKS.

ASTRONOMY.

A Compendium of Spherical Astronomy, with its applications to the determination and reduction of positions of the fixed stars, by Simon Newcomb (New York and London: Macmillan Co., 1906; pp. xv + 444; 12s. 6d. net).—This is the first of a projected series designed both for the student and the investigator, supplying the one with a condensed handbook which takes very little account of branches of purely theoretical interest, and the other with a *vade mecum*, containing just those formulæ and data which are necessary for the working out of practical applications by the shortest or most convenient method, thus saving what is often the most irksome part of his labour, which may be called "sparring for a hold." Part I. contains such general preliminaries as Approximations, Interpolation, Method of Least Squares, and Probable Error; Part II., Spherical Co-ordinates, Conversion to Different Axes, Solar and Sidereal Time, Parallax, Aberration, Refraction, Precession, and Nutation, having regard to the comparatively long periods now covered in catalogue comparisons. This last point is still more strongly emphasised in Part III., which deals with the actual reduction of stellar observations for epoch and apparent place, and also, of course, to the meridian, and with the comparison of catalogues and deduction of proper motions. A list of independent catalogues is given at the end of Part III., and an appendix follows giving tables for nearly every purpose referred to in the volume, and constants and formulæ in frequent use. Altogether a very valuable book, which we can confidently recommend.

BOTANY.

School Gardening for Little Children, by Lucy R. Latter (Swan Sonnenschein and Co.; 2s. 6d. net.)—An excellent little book, brimful of exactly the proper kind of information required by those whose duty it is to train children to observe and draw deductions for themselves. The garden proper is not the only thing utilized for the purpose of imparting information; the various forces that enable a garden to exist—light, heat, rain, wind, &c.—are also included, and the effect of each in turn furnishes an object lesson, hence the child is introduced unconsciously, and in the pleasantest of ways, to the elements of botany, physics, zoology, and, above all, the power of observation.

The wisdom of teaching what must at some time be unlearned is, perhaps, doubtful, and to a mind that is receiving first impressions, such terms as "seed-box," for fruit, "dust spikes," for stamens, and "sticky-head," for stigma, are not more explicit, neither more easily remembered, than the proper names of these structures.

PHOTOGRAPHY.

The Hand Camera Companion and Guide. Edited by the Rev. F. C. Lambert, M.A. (London: Hodder and Stoughton, 1906; 1s. net).—On the title page Mr. Lambert appears as the author, and presumably as these words are generally understood he has been more of an author than an editor in preparing this volume. Mr. Lambert is essentially a clear writer and well understands the beginner's wants. In a series of headed paragraphs he discourses concisely on hand cameras and their various parts, making negatives and printing from them, and the application of the processes described to all sorts of subjects. The page headings are carefully selected and there is a good index, so that although the work is not divided into chapters it is easy to find any required section. The volume contains a great many practical hints and useful suggestions that are not often found in print, and is well worth study by those who use, or are about to use, hand cameras.

The Photographic Picture Post-Card. By E. J. Wall, F.R.P.S., and H. Snowden Ward, F.R.P.S. **Magnesium Light Photography.** By F. J. Mortimer, F.R.P.S. (London: Dawbarn and Ward. 1s. net, each.)—Judging from the recent output of various publishers, the demand for small volumes dealing with just one section of photographic work seems to be increasing. This method of dispensing information, although not without its disadvantages, enables the buyer to get what he wants as he wants it, and often makes it possible for the publisher to secure a

specialist as author. Perhaps the chief objection to subdividing the subject and attempting to make each part complete in itself, is that there must be a large amount of overlap or of omission, for photography is one, whether magnesium light or daylight is used, and whether the print be a post-card or otherwise. Both these recent additions to one of Messrs. Dawbarn and Ward's series, are by men of practical experience in the subjects they treat of, and may be safely accepted as guides. The treatise on picture post-cards is divided into two parts: first, the making of them, and second, the making of money from them; and both volumes deal with the business or commercial side of the subject as well as the more strictly photographic side. The authors have made a judicious selection of subjects to treat fully, and have not omitted to refer to alternate processes.

PHYSICAL CHEMISTRY.

Higher Mathematics for Students of Chemistry and Physics. J. W. Mellor (Longmans; 15s. net.)—The rapid growth of physical chemistry has taught the chemist that unless he is equipped with a sound working knowledge of mathematics he stands at a disadvantage so great that he is practically excluded from a considerable region of his subject. The man who desires to go behind mere experiment to the general laws which enable results to be classified must acquaint himself with mathematics, for it is only in terms of mathematical symbols that these relations can be concisely expressed and deductions from them made. This book, which now appears as a second and considerably enlarged edition, is intended to provide such a selection from the various departments of mathematics as may subserve the needs of such a student. It is not for the mathematical specialist, and consequently what the author considers "tedious demonstrations" are sometimes avoided by merely making reference to the "regular text-books." The aim throughout is to make the student alive to the real meaning of mathematical expressions by means of examples selected from work with which he is otherwise familiar.

Although it is probably the chemist who will be most attracted, a great number of the problems are of a purely physical nature. It is doubtful whether it was worth while to cater for the physicist, who presumably will receive a training in a more formal way; but, of course, many will be glad of the assistance which the book affords. And to them we would say that there is no branch of physics which does not contribute to the examples here analysed. The chemist would find it more useful if many of these problems were not present. The book appears to be carefully edited; we have noticed only a few misprints. But in some places the sentences might be made less ambiguous if re-written differently.

SCHOLASTIC.

A Guide to the Electrical Examinations. F. H. Taylor, A.M.I.M.E. (Percival Marshall and Co., 1s. net, paper; 1s. 6d. net, cloth.)—The examinations referred to are those of the City and Guilds Department of Technology, and of the Board of Education. Besides general particulars and syllabuses the book contains selected questions from recent examinations, many of which are worked out in detail; it contains also hints on the preparation for examinations and on the working of examination papers. A considerable amount of condensed information is provided.

Elementary Modern Geometry. H. G. Willis, M.A. Part I. (Clarendon Press, Oxford, 2s.)—These lessons are, in part, experimental, in part theoretical. The modern idea is followed according to which it is sought first to familiarize a student experimentally with the more important theorems and problems; he is then in a better position to understand the more strict mathematical logic by which they are later on examined. With this method we are in thorough agreement, though we recognise that there exist those to whom it will be very repugnant. No attempt has been made to follow Euclid's sequence.

Examples in Physics. C. E. Jackson, B.A. (Methuen; price 2s. 6d.)—This book will prove very valuable to the teachers in secondary schools, as it provides a very large number of problems ranging in difficulty from those of very elementary kind to many of a more advanced kind suitable especially to those who are reading for University Scholarships. None of these problems are worked out as illustrations; hence the book cannot be used alone. Besides several sets of examples arranged according to subject, there is a series of problem papers in which mixed examples are given. Answers are provided only to the former. We think that it would be better to provide answers to all. In those cases in which a teacher may wish to set questions for special test purposes it is very easy for him to slightly alter the numerics so as to prevent the student getting a "lead." The presence of answers makes for utility to the private student.

ZOOLOGY.

Serials. — We have to acknowledge the receipt of copies of the first two numbers (May and June) of a new scientific serial, the (Haslemere) *Museum Gazette*, whose special purpose is to forward the interests of objective education and field study. Many of the articles in the first number are excellent, and there are some good photographs in both. We fear, however, that the articles on camels and deer and on gnus in the second volume are scarcely calculated to impress naturalists with the value of the new teaching. We are told, for instance, in the first of these, that camels and deer form a single family of ruminants, and that adult camels have no upper incisors and pair less of lower ones than giraffes. This blunder is, however, eclipsed by the following sentence: "All the gnus are South African and would appear to bear the same relation to the buffaloes of that continent that the North American bison does to the American buffalo."

We have also received from the University of California copies of papers on the ostracod crustaceans, of the family *Halocyprida*, on the shore-anemone, *Bunodactis xanthogramma*, and on sexual dimorphism in the hydroid polyps of the genus *Aglaophenia*. The dimorphism in the latter group displays itself in the plumules.

The Menageries of Europe. — Captain Stanley Flower, Director of the Zoological Gardens at Giza, Egypt, has favoured us with a copy of a report of a mission undertaken by himself last year to visit the chief Zoological Gardens in Europe, in which much interesting information with regard to these establishments and their inhabitants will be found.

MISCELLANEOUS.

Thought-Transference, by N. W. Thomas, M.A. (De La More Press; pp. 212 and index, 3s. 6d. net).—This work is a critical and historical review of the evidence for telepathy, and records a number of new experiments carried out in 1902 and 1903. It is full of interesting and thoughtful matter on this much-discussed subject, and will afford much entertainment and food for thought to those who have attempted at any time to unravel some of its tangled problems.

E. A. M.

Crystal-Gazing, by N. W. Thomas, M.A. (De La More Press; pp. 159 and index, 3s. 6d. net).—This work has an introduction by Andrew Lang, and gives a history of the practice of crystal-gazing. The subject is dealt with from a critical point of view. A crystal does not seem to be always a necessity, the mental image resulting being capable of production merely through intent gazing into many other more prosaic substances. An interesting experience in connection with Mr. Balfour and Miss Balfour is related in Mr. Lang's introduction.

E. A. M.

The Unity of Will, by George Ainslie Hight (London: Chapman and Hall), 1906; 10s. 6d.—The author's aim is ambitious, inasmuch as he endeavours to provide us with a new philosophy, a task for which, to our thinking, he is but indifferently qualified. There is a lack of cogency in his arguments, while in many cases he absolutely misinterprets, and misrepresents; as for example, when he defines Agnosticism as "denying and reviling all gods." His chapter on the "Sophistries of Science," seems to us crude. Imbued with what he calls "the divine teaching of Plato," an ardent disciple of Schopenhauer, and a "Vedântist," he looks on the world through distorted glasses, and would have us believe that what *he* sees is true, and only that!

XUM

MICROSCOPY

Conducted by F. SHILLINGTON SCALES, B.A., F.R.M.S.

The Use of the Camera Lucida.

THERE are several ways of recording the appearance of an object as seen in the microscope. Of these the photo-micrograph is considered the most trustworthy, as it gives no variation with regard to the powers of observation and individual opinions of the observer, powers of observation which vary with the observer's skill and experience, and opinions which too often enable him to persuade himself to see what he wishes to see, and which bias him accordingly by preformed hopes or expectations. From the result of personal idiosyncrasies of this sort the photo-micrograph is free, and it has even a peculiar property of its own in increasing slightly the resolving and, therefore, the defining power of an objective, but it has none the less great disabilities. It takes no account of variations of focus, and the higher the power and the greater the aperture of an objective, the more is the resulting photograph limited to a single plane, with all that this involves. It also takes no account, or even an apparently distorted account, of differences in colour, and an object which has been carefully differentiated by selective stains for visual examination may, as a photo-micrograph, be confused and misleading in spite of all the colour screens and mono-chromatic methods of illumination that experience can suggest. Therefore we are frequently thrown back on the pen and pencil as a means of recording what we see for future reference or for the information of others.

For such pen and pencil methods the simplest plan of all is to look down the microscope tube with one eye and to record the result upon a piece of paper placed conveniently at one's right hand. But the drawbacks of such a method of procedure are manifest, and not the least of these is the difficulty in keeping the details in place and in proportion. The methods used, therefore, come under two heads—the projection of the image bodily upon a sheet of paper, and the tracing of it there *in situ*, or the use of an apparatus which enables us with one and the same eye to see both the image and the paper, and to draw each line of the former in its proper position.

The projection method requires the use of a projection microscope, an enclosed light, a darkened room, and preferably a right angle prism to project the image down upon the paper as it lies upon the table, though I have seen more or less unsatisfactory attempts made to do this by means of a prism, such as the Wollaston prism, attached merely to the eye-piece of the microscope. It is fairly successful with low powers, but with high powers the loss of light is prohibitive, to say nothing of the other disadvantages inherent in this method.

The camera lucida as ordinarily used brings the microscopical image and the paper into view at the same time and in the same place. Of the many forms of apparatus the simplest, the least expensive, and in some hands not the least satisfactory, is Beale's well-known form. As originally designed by Amici this was a piece of plain glass set at an angle of 45° across the eye lens of the ocular, the tube of the microscope being placed in a horizontal position and the observer looking down through the glass at the paper beneath. By this means he saw the paper directly, whilst the microscopic image was reflected up into his eye. There was, however, a troublesome and, indeed, fatal double reflection from the inner surface of the glass, and Dr. Beale got over this difficulty by the simple expedient of using tinted glass. Such a camera lucida can now be bought for a few shillings, or can even be home-made by anyone possessed of a little ingenuity. Its main defect is that the image is inverted though not transposed, and this renders the subsequent filling in of details more troublesome and more liable to error and confusion.

Wollaston's camera lucida is a form that was early introduced, and in many hands has also done good work, but is now more or less obsolete. It consisted of a prism covering the whole of the eye-lens of the ocular, and this prism was so constructed that it gave two reflections and so transmitted the image to the eye neither inverted nor transposed. The microscope was used in the horizontal position, and the eye was so adjusted that half of the pupil looked into the prism and the other half down upon the paper. Any variation in the position of the eye, therefore, caused the two fields of view to become unequally illuminated, and the difficulty of keeping the eye rigidly in the necessary position caused this form of camera to fall into disuse as other and better forms were evolved.

The camera lucida most used nowadays is that designed or adapted by Abbe. It consists in its simplest form of a ring to clamp around the eye-piece end of the microscope, this ring carrying a projecting arm to which is attached a mirror set at an angle of 45° or so with the axis of the microscope. This mirror reflects the image of the paper into a small silvered mirror placed above the ocular, thus reflecting the paper into the eye. This latter mirror is perforated by a small circular hole which enables the eye at the same time to look directly down the microscope tube; in fact, the eye is really looking through a cube of glass cut diagonally and with one of the diagonal surfaces silvered and pierced as just described.

The same principle is adopted in the combined camera lucida and eye-piece sold by most opticians, which, though less effective, are certainly more compact, a mirror much reduced in size or a prism taking the place of the large Abbe mirror.

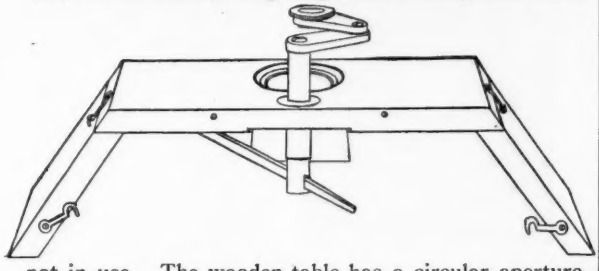
In all forms of camera lucida, other than those of the direct projection type, the great difficulty is the adjustment of the illumination so that neither microscopic image nor paper overpower each other in brightness, the former varying greatly according to illuminant, condenser, diaphragm, and magnification, whether of objective or ocular. To avoid this, Abbe's camera lucida in its most elaborate, and, unfortunately, its most costly form, has a system of differently tinted glasses, one set of which is used to adjust the brightness of the image from the paper, and the other set to adjust the brightness of the microscopic image. There is also a change of prism above the ocular with a different aperture for use with different objectives, and even an elaborate centring mechanism.

The use of the camera lucida always requires a certain amount of practice, but the initial difficulties will be rapidly overcome if the necessity for careful adjustment of the two illuminations is borne in mind. The differently tinted glasses are of great service, and much can be done by careful adjustment of the condenser diaphragm, but, perhaps, the most useful hint that can be given to the beginner is to suggest the use of two lamps—one to illuminate the paper and one to illuminate

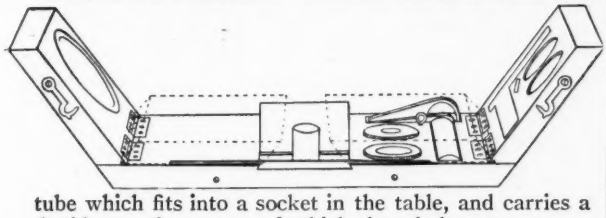
the microscope. A little juggling with the two lamp-wicks will often work wonders. Another suggestion that can be made is to blacken the end of the pencil or to tip it with gold-leaf. Finally, distortion of the drawing must be guarded against, especially with forms like the Abbe apparatus, which can be used with the microscope slightly inclined, and, if necessary, an inclined drawing-board must be used.

New Portable Dissecting Microscope.

Messrs. R. and J. Beck have brought out a new dissecting microscope which is not only portable, but when folded up contains all the necessary apparatus packed into the thickness of the wood, so that there are no projections or loose pieces. The illustrations make the principle clear, the two side flaps, which spread out as rests for the hands, being hinged and folding back when



not in use. The wooden table has a circular aperture into which drops a white porcelain saucer, which is concave on one side and flat on the other, and can be used either way up, or a piece of transparent glass may be used in place of the saucer, in which case light may be thrown from below by means of a folding flap which carries a white reflector. The lens carrier consists of a



tube which fits into a socket in the table, and carries a double arm by means of which the whole aperture can be examined. The vertical adjustments are made by means of a lever. The whole apparatus, with two single lenses, saucer, glass plate, focussing adjustment, and two needles packs into a space 9 ins. by $3\frac{3}{4}$ ins. by $1\frac{1}{8}$ in., and costs 35s.

A New Application of the Abbe Condenser

The "Journal" of the Royal Microscopical Society summarises some observations of a Continental worker which are based on the fact that the Abbe condenser presents a real, reversed image of the source of illumination. If an object, such as a micrometer scale, be suitably interposed, an image of this will be similarly formed on the stage, and may be applied to measuring an object there. In this way, by the help of a proportionately stronger objective, a series of magnifications can be obtained which are very convenient for drawing, and for the preparation of various objects. The size of the image formed above the front lens (viewed from above) of the condenser depends on the distance of the object from the under-lens; the image is smaller as the distance is increased. Thus it will be seen that the series of magnified images thrown on to the stage will vary from zero to a maximum. This image can be combined with various powers of objective, eye-piece, and tube-length, and thus the series of attainable effects is practically infinite, although only observations in the middle of the field will be free from sensible distortion. Instead of the condenser, weak achromatic objectives might be used. A difficulty would, no doubt, lie in the construction of a suitable adjustable stage for the object; the author, however, sees his way to a proper design. He summarises the advantages of this proposal as:—(1) The facility for orientating objects which can be afterwards examined in the usual way. (2) The formation of graduated magnifications by which an operator who wishes to draw from a weak magnification can easily select the most suitable power. (3) The property possessed by the Abbe (thus used) in combination with an objective of forming an erect image. (4) If a plane mirror be used, and the object inserted between the light-source and the mirror, an erect microscope becomes virtually a horizontal one, and may thus be used, for example, as an aquarium microscope. (5) As the magnification may be zero, the arrangement may be applied to the drawing of objects in their natural size.

Temporary Mounting of Objects.

It often happens that objects are required to be mounted temporarily only, and without the more elaborate processes which are necessary for permanent mounting. Such objects can be mounted in a drop of the preservative, or in water, or in alcohol and formalin according to the medium in which the object may be, whilst normal salt solution (common salt .6 per cent. in water) is often of great use. Living objects are best mounted in their natural medium, as any change may alter their appearance, or, at least, inhibit their movements. In all these cases, however, rapid evaporation of the liquid takes place, and some means of sealing the cover-glass is necessary. For this purpose vaseline, castor-oil, or glycerine jelly have all proved useful, and a method that is of service in many cases, especially where what are known as "hanging drops" are being dealt with, is to use a paraffin match, or a toy wax candle by blowing out the light, and whilst the paraffin is still liquid running it like a brush along the edge of the cover-glass. In all cases it is necessary to have sufficient of the mounting medium to prevent soft objects from being crushed, and, on the other hand, to avoid any excess which would cause the cover-glass to float, or to spread beyond the edges. Such surplus can readily be removed with blotting paper, care being taken lest the capillary attraction draws too much liquid from beneath the cover-glass. It is well to lower the cover-glass edgewise gently upon the object in order to avoid bubbles.

John Wheldon and Co.'s Catalogue.

Messrs. John Wheldon and Co., of 38, Great Queen Street, W.C., have just issued a catalogue of books and papers on Microscopical Science in all its branches, which contains many interesting items, including numerous books on the microscope itself.

Microscopical Material.

Mr. J. Sculthorpe, of Bath, has kindly sent me for distribution a considerable quantity of sea-sand from an unknown locality, which well repays looking over under the microscope, and from which interesting marine débris can be picked out. I shall be glad to send an ounce or two of this to anyone who applies for it. Applications must be accompanied by a stamped and addressed envelope, a wooden or tin box, and the coupon to be found in the advertisement pages of this issue.

[*Communications and Enquiries on Microscopical matters should be addressed to F. Shillington Scales, "Jersey," St. Barnabas Road, Cambridge.*]

XUM

The Face of the Sky for September.

By W. SHACKLETON, F.R.A.S.

THE SUN.—On the 1st the Sun rises at 5.12 and sets at 6.47; on the 30th he rises at 6.0 and sets at 5.41.

The Sun enters the sign of Libra on the 23rd at 11 p.m., when autumn commences.

The equation of time for sundial purposes is negligible on the 1st and 2nd, hence these dates are convenient for the adjustment of dials, as only the longitude correction is needed. Sunspots may usually be observed on the Solar disc, but there is a noticeable diminution both in number and size, indicating that we are well past the maximum.

The positions of the Sun's axis, centre of the disc, and heliographic longitude of the centre are given in the following table:—

Date.	Axis inclined from N. point.	Centre N. of Sun's Equator.	Heliographic Longitude of Centre of Disc.
Sept. 3 ..	21° 41′ E	7° 14′	280° 22′
,, 8 ..	22° 51′ E	7° 15′	214° 17′
,, 13 ..	23° 52′ E	7° 13′	148° 17′
,, 18 ..	24° 43′ E	7° 7′	82° 17′
,, 23 ..	25° 24′ E	6° 57′	16° 17′
,, 28 ..	25° 56′ E	6° 47′	310° 19′

THE MOON:—

Date.	Phases.	H. M.
Sept. 2 ..	○ Full Moon	11 36 p.m.
,, 10 ..	☾ Last Quarter	8 54 p.m.
,, 18 ..	● New Moon	0 34 p.m.
,, 25 ..	☽ First Quarter	6 12 a.m.
,, 10 ..	Apogee	0 54 a.m.
,, 22 ..	Perigee	0 18 a.m.

OCCULTATIONS.—The following are the particulars of the principal occultations visible from Greenwich; it will be noticed that the 1st magnitude star Aldebaran suffers occultation on the morning of the 10th:—

Date.	Star's Name.	Magnitude.	Disappearance.		Reappearance.	
			Mean Time.	Angle from N. point.	Mean Time.	Angle from N. point.
			p. m.		p. m.	
Sept. 9	75 Tauri	5·3	10 19	43°	11 7	286°
,, 9	B.A.C. 1391 ..	4·9	11 14	116°	11 58	211°
			a. m.		a. m.	
,, 10	α Tauri	1·1	2 27	149°	2 43	174°

THE PLANETS.—Mercury (Sept. 1, R.A. 9h 31m; Dec. N. 15° 3′; Sept. 30, R.A. 12h 43m; Dec. S. 3° 38′) is in superior conjunction with the Sun on the 24th, and hence is unobservable towards the end of the month; during the earlier part of the month the planet is a morning star in Leo, and being near the point of greatest elongation is favourably placed for observation. On the 9th the planet rises at 4.2 a.m., whilst on the 6th he is situated about 1° north of Regulus.

Venus (Sept. 1, R.A. 13h 25m; Dec. S. 10° 28′; Sept. 30, R.A. 15h 16m; Dec. S. 22° 13′) is at greatest easterly elongation of 46° 29′ on the 20th. During the month the planet moves from an apparent position close to Spica on the 1st to one in Libra on the 30th. As seen in the telescope the planet has the phase of "half moon," 0·51 of the disc being illuminated. On the 15th the planet sets at 7.25 p.m.

Mars (Sept. 1, R.A. 9h 43m; Dec. N. 14° 58′; Sept. 30, R.A. 10h 53m; Dec. N. 8° 26′) is a morning star in Leo, rising about 3.30 a.m. throughout the month. The planet is in conjunction with Mercury on the morning of the 5th, Mercury being 10′ to the South.

Jupiter (Sept. 1, R.A. 6h 26m; Dec. N. 23° 2′; Sept. 30, R.A. 6h 42m; Dec. N. 22° 51′) is a morning star in Gemini, rising about 10.45 p.m. on the 15th.

Saturn (Sept. 1, R.A. 22h 57m; Dec. S. 9° 1′; Sept. 30, R.A. 22h 49m; Dec. S. 9° 50′) is an evening star describing a retrograde path in Aquarius, and is well placed for observation, being due south at 11 p.m. on the 19th, when he rises at 5.45 p.m. The planet is in conjunction with the moon on the morning of the 3rd, at 3 a.m.—the Moon being "full." As seen in this country, the planet will appear to be about 1° 15′ from the northern limb of the moon, as shown in the diagram.

We are looking on the northern surface of the ring, the outer major and minor axes of which are 44″ and 4″ respectively, whilst the apparent diameter of the ballis 17″·6.

The planet is in opposition to the Sun on the 5th at 3 a.m., hence near this date he is on the meridian about midnight.

Uranus (Sept. 15, R.A. 18h 20m; Dec. S. 23° 41′), though rather low down in the sky, is fairly well placed for observation during the early evening, and is due south shortly after sunset. The planet is situated in Sagittarius in a part of the sky devoid of good reference stars, though the star μ Sagittarii is some 3° to the N.W.

The planet is at the stationary point on the 14th, after which his motion is direct or easterly, whilst on the 28th he is in quadrature with the Sun, and hence near this date he crosses the meridian about 6 hours after the Sun.

Neptune (Sept. 15, R.A. 6h 53m; Dec. N. 22° 0′) rises about 11.15 p.m. near the middle of the month, and hence is not in a favourable position for observation before midnight; the planet is situated about 1° north of the star ξ Geminorum.

Minima of Algol occur on the 10th, at 10.48 p.m., and on the 13th, at 7.37 p.m.

TELESCOPIC OBJECTS:—

Double stars: ζ Ursæ Majoris XIII.h 20m, N. 55° 25′, mags. 2, 4; separation, 14″·4.

ξ Aquarii XXII.h 23m, S. 0° 35′, mags. 4, 4, separation 3″·2. Both components are yellowish,

β Cygni XIX.h 27m, N. 27° 46′ mags. 3, 5; separation 34″. The brighter component is yellow, the other blue; very easy double in small telescopes with a power of 20.

Cluster (M 11) in Aquila or Antinous. R.A. 18h 46m; Dec. S. 6° 23′. Very pretty object for 3 or 4 inch telescope; it is an easily resolvable fan-shaped cluster, with an 8th magnitude star in apex and an open pair of the same magnitude just outside it.

(M 8) Cluster in Sagittarius; large luminous field of small stars; fine object in pair of field glasses. About a degree E. of the star 4 Sagittarii.